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Gregory, Jr. et al.

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[54] **CHARACTERIZATION CALIBRATION**

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[21] Appl. No.: **407,785**

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Related U.S. Application Data

[63] Continuation of Ser. No. 86,978, Jul. 2, 1993, abandoned, which is a continuation-in-part of Ser. No. 58,082, May 4, 1993, abandoned, which is a division of Ser. No. 832,358, Feb. 7, 1992, Pat. No. 5,208,911, which is a division of Ser. No. 717,099, Jun. 18, 1991, abandoned.

[51] **Int. Cl.**^{6} **G06K 9/00**; G02B 5/12

[52] **U.S. Cl.** **382/167**; 358/504; 358/518; 358/523; 345/431

[58] **Field of Search** 382/100, 162, 382/167; 358/504, 518, 523; 395/109, 131; 345/431; 364/556, 571.01

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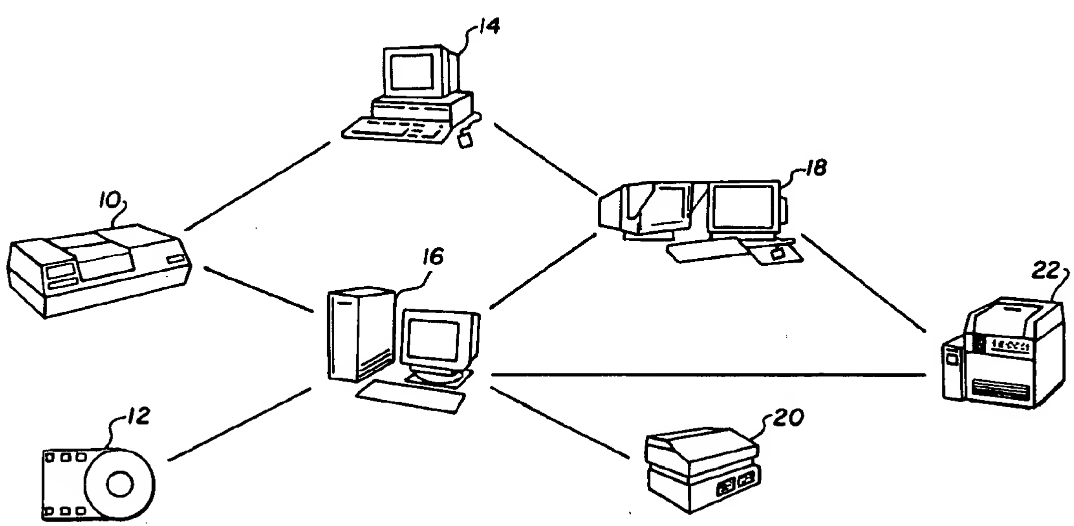
[57] **ABSTRACT**

The output response of an image processing system having a color printer and a color printer characterization is linearized by printing a target image having target patches of differing color densities. After measuring printed patches, a calibration transform is generated that incorporates the relationship between requested and measured color densities. The calibration transform is then composed with the characterization, calibrating the printer characterization.

21 Claims, 8 Drawing Sheets



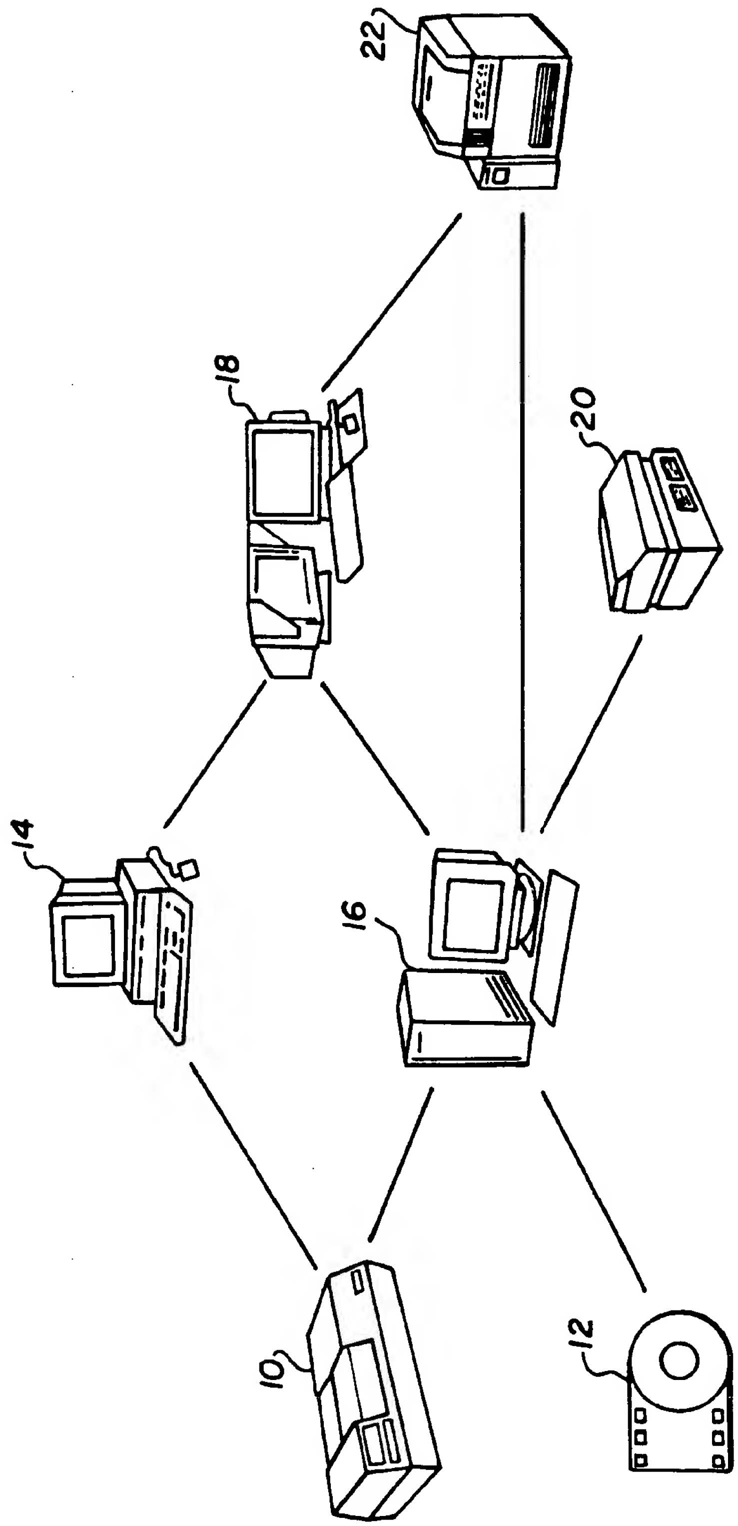


FIG. 1

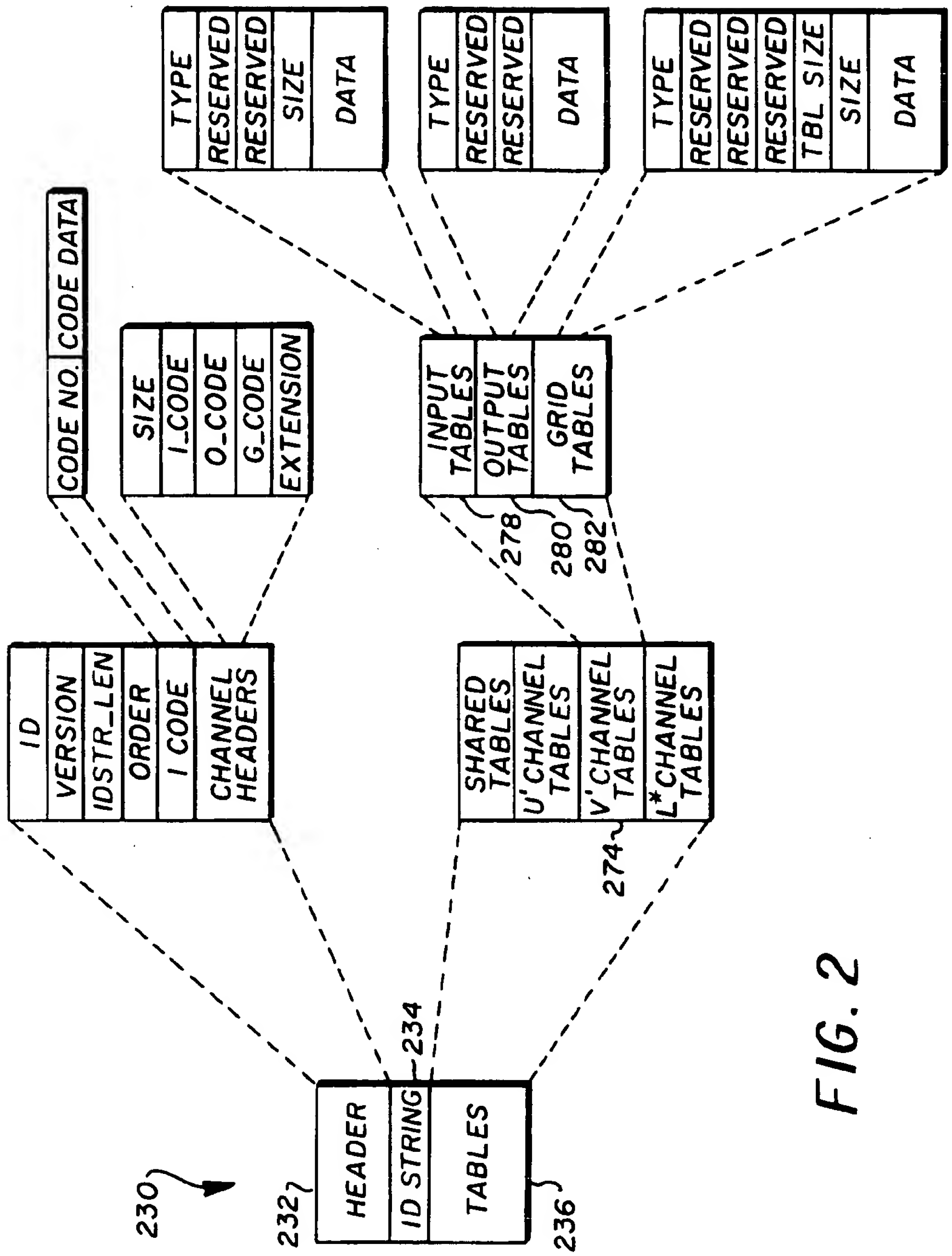

TYPE
RESERVED
RESERVED
SIZE
DATA
TYPE
RESERVED
RESERVED
DATA
TYPE
RESERVED
RESERVED
RESERVED
TBL_SIZE
SIZE
DATA
CODE NO.
CODE DATA
SIZE
I_CODE
O_CODE
G_CODE
EXTENSION
INPUT TABLES
OUTPUT TABLES
GRID TABLES
278
280
282
ID
VERSION
IDSTR_LEN
ORDER
I CODE
CHANNEL HEADERS
SHARED TABLES
U'CHANNEL TABLES
V'CHANNEL TABLES
L*CHANNEL TABLES
274
234
230
232
HEADER
ID STRING
TABLES
236

FIG. 2

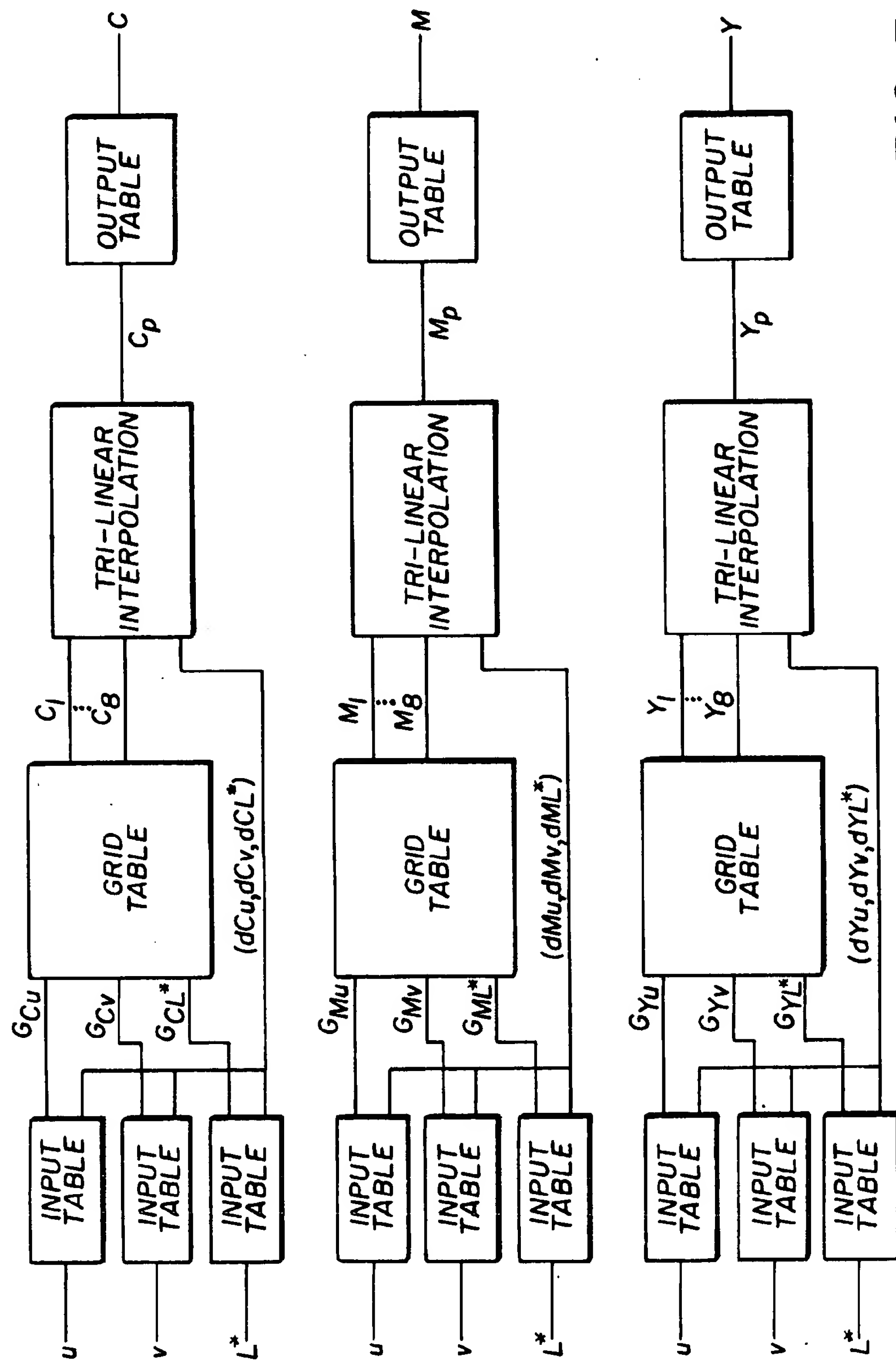

INPUT TABLE
GRID TABLE
TRI-LINEAR INTERPOLATION
OUTPUT TABLE
u
v
L*
G_{Cu}
G_{Cv}
G_{CL^*}
(dCu, dCv, dCL^*)
C_1 ⋮ C_8
C_p
C
G_{Mu}
G_{Mv}
G_{ML^*}
(dMu, dMv, dML^*)
M_1 ⋮ M_8
M_p
M
G_{Yu}
G_{Yv}
G_{YL^*}
(dYu, dYv, dYL^*)
Y_1 ⋮ Y_8
Y_p
Y

FIG. 3

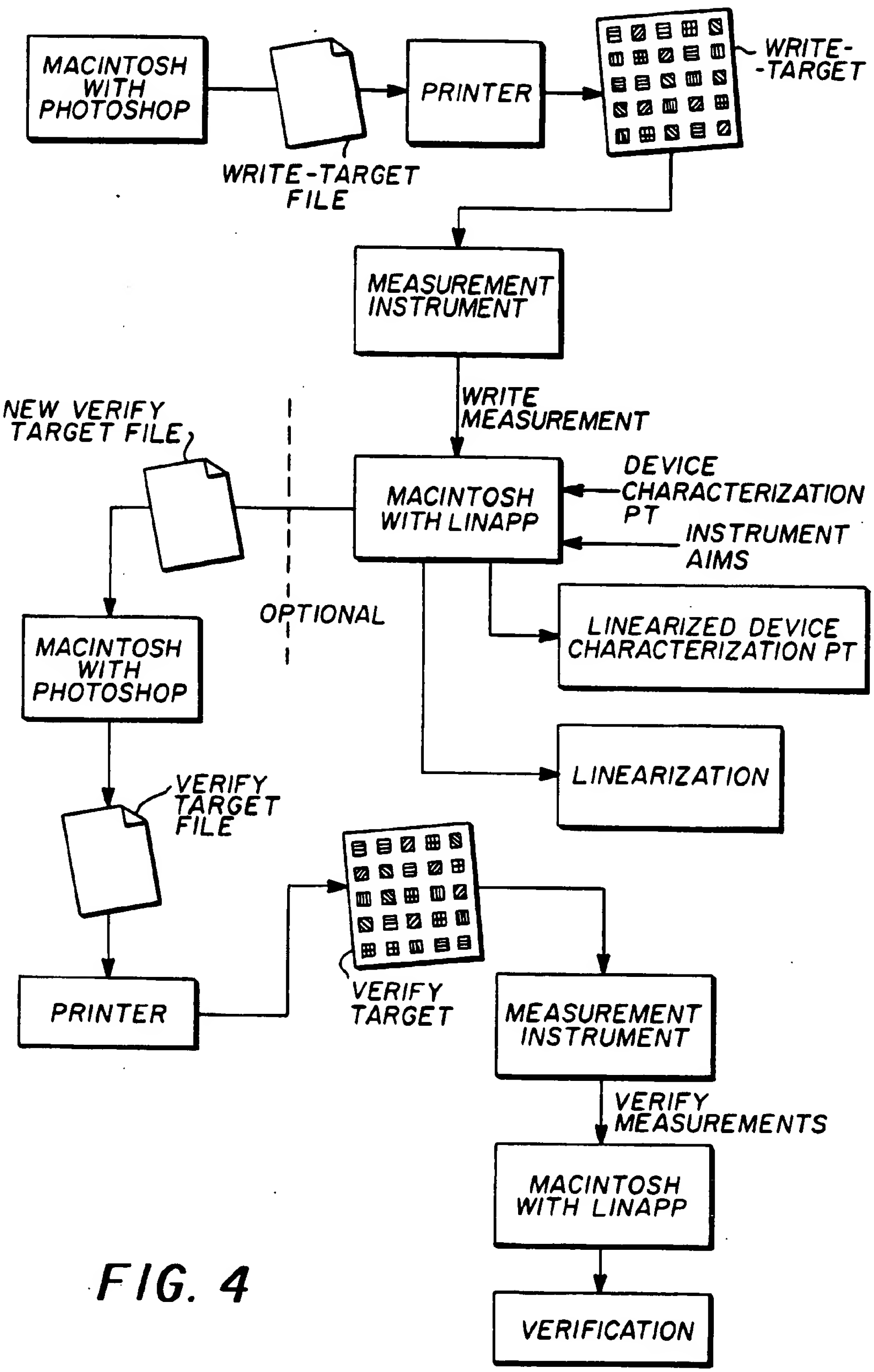
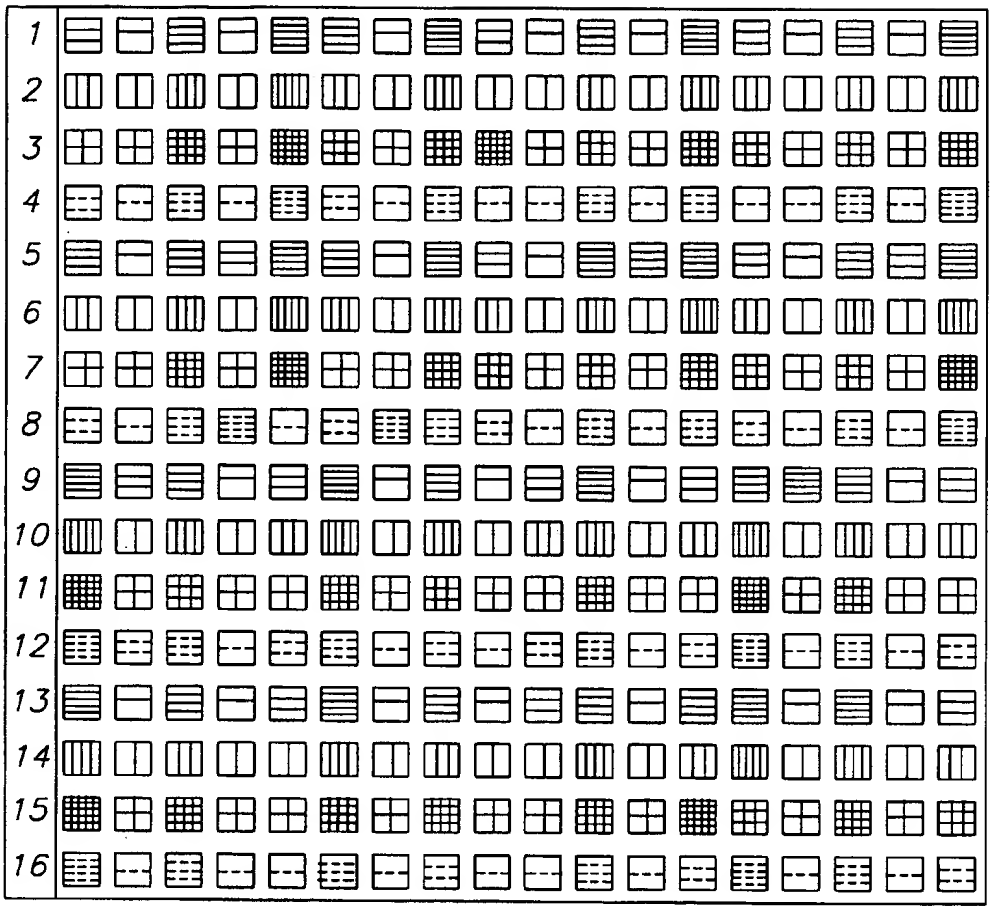

MACINTOSH WITH PHOTOSHOP
WRITE-TARGET FILE
PRINTER
WRITE-TARGET
MEASUREMENT INSTRUMENT
WRITE MEASUREMENT
NEW VERIFY TARGET FILE
OPTIONAL
MACINTOSH WITH LINAPP
DEVICE CHARACTERIZATION PT
INSTRUMENT AIMS
LINEARIZED DEVICE CHARACTERIZATION PT
LINEARIZATION
MACINTOSH WITH PHOTOSHOP
VERIFY TARGET FILE
PRINTER
VERIFY TARGET
MEASUREMENT INSTRUMENT
VERIFY MEASUREMENTS
MACINTOSH WITH LINAPP
VERIFICATION

FIG. 4



KEPS 4 colorant linearization target (400% stabli.), this end prints last.

FIG. 5

Verify Target.4Color.rOPs-Linearize

PATCH NUMBER: 6-M,A

ACTUAL VALUE: 0.445

	A	B	C	D	E
1-L					
2-M					
3-Y					
4-K					
5-C	0.554	0.165	1.031	0.402	2.048
6-M	0.445	0.183	0.858	0.338	1.759
7-Y	0.357	0.116	0.734	0. 253	1.845
8-K	0.575	0.198	0.87	0.364	1.487
9-C	1.724	0.356	0.981	0.146	0.564
10-M	1.413	0.312	0.81	0.168	0.465
11-Y	1.397	0.221	0.694	0.111	0.352
12-K	1.288	0.319	0.808	0.181	0.532
13-L					
14-M					
15-Y					
16-K					

FIG. 6

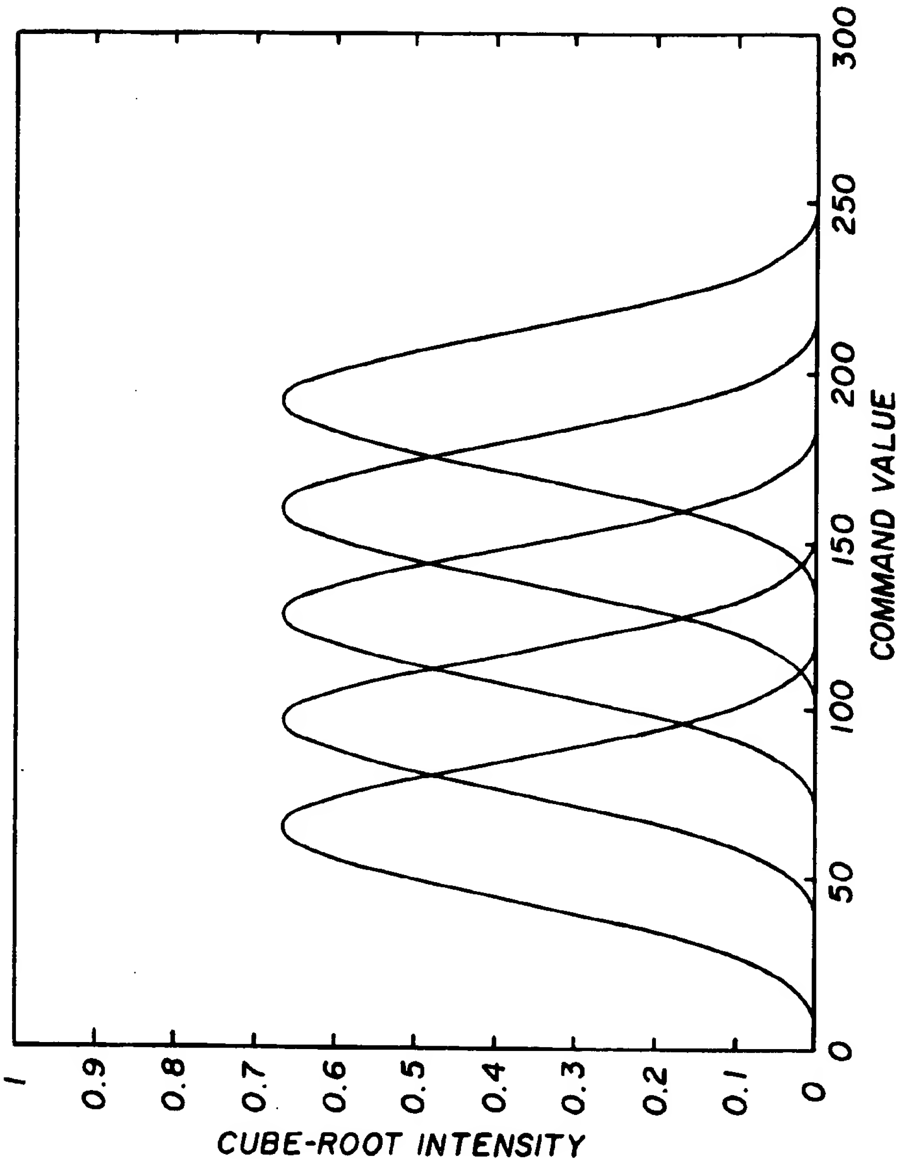

CUBE-ROOT INTENSITY
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
COMMAND VALUE
0
50
100
150
200
250
300

FIG. 7

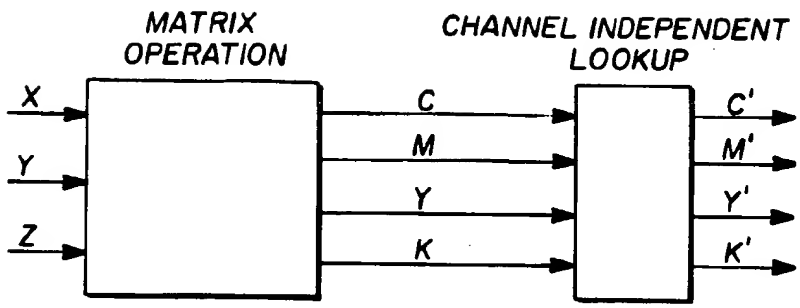

MATRIX
OPERATION
CHANNEL INDEPENDENT
LOOKUP
X
Y
Z
C
M
Y
K
C'
M'
Y'
K'

FIG. 8

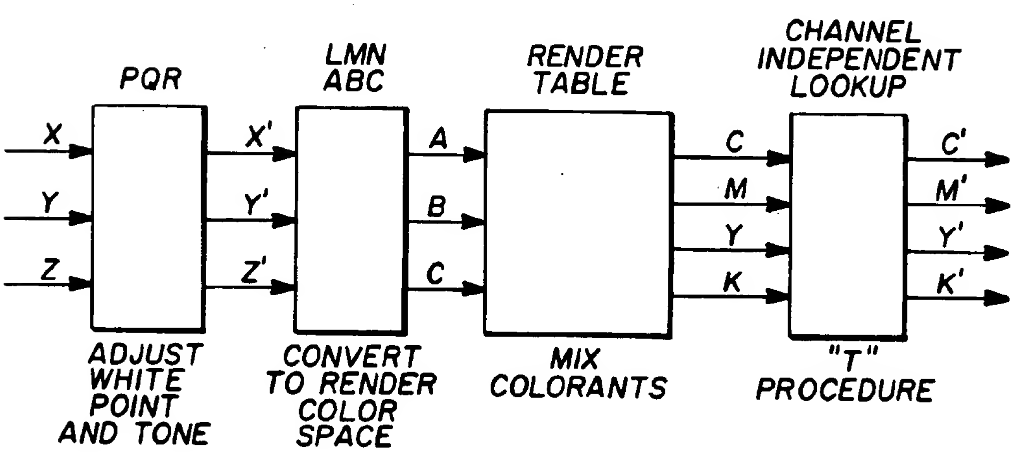

PQR
LMN
ABC
RENDER
TABLE
CHANNEL
INDEPENDENT
LOOKUP
X
Y
Z
X'
Y'
Z'
A
B
C
C
M
Y
K
C'
M'
Y'
K'
ADJUST
WHITE
POINT
AND TONE
CONVERT
TO RENDER
COLOR
SPACE
MIX
COLORANTS
"T"
PROCEDURE

FIG. 9

CHARACTERIZATION CALIBRATION

RELATED APPLICATIONS

This is a Continuation of U.S. application Ser. No. 08/086,978, filed 2 Jul. 1993 now abandoned, which is a continuation-in-part of U.S. patent application Ser. No. 08/058,082 entitled "Color Image Processing System for Preparing a Composite Image Transformation Module for Performing a Plurality of Selected Image Transformations," filed May 4, 1993, now abandoned which is a division of U.S. application Ser. No. 07/832,358, filed Feb. 7, 1992, now issued as U.S. Pat. No. 5,208,911, which is a division of U.S. application Ser. No. 07/717,099, filed Jun. 18, 1991, now abandoned.

FIELD OF THE INVENTION

The invention relates to the general field of electronic processing of color images, and in particular to methods and apparatus for calibrating color characteristics of printers and output devices.

BACKGROUND

Color image processing systems typically include a combination of devices, including input devices (e.g., a scanner), image manipulation devices (e.g., a workstation) and output devices (e.g., a printer). When combining diverse input/output devices, consistency of color reproduction is desirable. For example, an operator who modifies an image to achieve particular color goals would like the printed image to have the same colors as a version seen on a CRT monitor. In another example, an operator would like an image to have nearly the same colors when printed on different printers, or when printed at different times on the same printer. Here, the phrase "same colors" implies "visual match".

This goal can be achieved by determining the relation between the command code values used to drive each device and the visual colors reproduced by that device in response to these values. This relation can then be inverted mathematically to establish a relation between visual colors and the command codes required to obtain these colors from the device. The process of determining this relation is known as "color characterization". If the color peripheral devices in a system have been characterized, it is possible to reproduce the same colors on these devices by selecting, for each device, the command code values that are required to reproduce those colors. The desired colors in an image can be specified in a device-independent, visual color space. The conversion from the visual color space to the command code values for each device is based on the characterization of that device. Examples of such visual color spaces are the "CIE-based color spaces" employed in PostScript® Level 2.

Color characterization generally involves the production of color patches by a given device in response to selected command code values. These patches are then analyzed in a colormeasurement laboratory, employing suitable optical instruments, such as spectroradiometers, to determine the optical properties of the patches. Calculations based on an understanding of human color vision can then be applied to the optical data to determine the visual colors of the patches. These techniques belong to the science of colorimetry.

The color-reproduction characteristics of printers and other devices vary considerably. Some of this variation is due to the different printing processes or technologies employed, such as thermal wax transfer, dye sublimation, electrophotography, ink jet, offset lithography, or gravure.

Some of these processes use continuous-tone deposition of the colorants, while others involve halftone screening or dithering of small dots in specific patterns. Even when devices use the same technology, considerable variation can be found from printer to printer due to the inevitable variability of the manufacturing process. In fact, the characteristics of a single printer will change or drift in the course of time, owing to aging and wear of parts and materials, temperature and humidity sensitivities, etc.

Unfortunately it is not practical to provide characterizations and periodic re-characterizations for large numbers of individual devices. Device characterization that takes into account many aspects of the device (screening, dot gain, ink spectral reflectance, . . .) tends to require expensive, precision instrumentation not typically available to most endusers of a color system. Thus, a "standard" characterization for a particular model printer tends to be generated once "at the factory" of the printer manufacturer or by an after-market supplier of characterizations. One example of a characterization is a Device Profile sold by Kodak Electronic Printing Systems, Inc. as part of its Precision Color Management system of products.

Device characterization significantly improves accuracy and repeatability of color generation by compensating for differences among different models of devices. However, even within one model of device, individual units exhibit characteristics that may differ over time (for the same unit) or that may differ from one unit of the same model to the next. Thus, after acquiring a particular model of printer and a characterization for that printer, end users may continue to suffer inaccuracies if the characteristic of the particular unit differs from the characteristic for which the "standard" characterization was made, or if the characteristics of the end user's particular unit drift over time.

SUMMARY OF THE INVENTION

The invention provides a practical means of generating color characterizations for individual color printers and similar devices by combining a standard characterization with specific calibrations for these devices.

For each colorant channel of the device—typically, red, green, and blue (RGB), or cyan, magenta, yellow, and black (CMYK)—a sequence of interface code values is defind, each of which is associated with a particular, measurable response of the device. The response is specified in advance by the designer of the interface and, accordingly, is called the "aim response". The response is "measurable" by means of an inexpensive instrument, such as a densitometer, which is capable of determining some optical property of the device's printed output, such as Status A density, which effectively monitors the condition of the printer.

In practice, a standard "target" image is printed by driving the printer with a sampling of the possible command code values in order to obtain samples of the printer output. The printer output samples are measured (e.g., using a standard densitomer), and the measured values are entered into the imaging system computer. The computer can then establish the relation between command code value and measured response for each colorant channel. The inverse of this relation maps response to command value. When this relation is applied to the aim responses for the interface code values, the computer creates a distinct transformation from the interface code values to the device's command code values. The device is now calibrated, in the sense that a given interface code value passed through this transformation will yield a command code value which will drive the

device to produce a print satisfying the aim response for that interface code value. When viewed from the internal interface, the device is "on aim"—i.e., equivalent to a standard printer of that unit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a system embodying the present invention;

FIGS. 2 and 3 are illustrations of a transform definition, including details of an input table, a grid table, and an output table;

FIG. 4 is a flow diagram illustrating steps for calibrating a device according to the present invention;

FIG. 5 is an illustration of a linearization target;

FIG. 6 is an illustration of a data input screen for manually entering density data measured from a print of the target of FIG. 5;

FIG. 7 is a plot illustrating basis functions of a B-spline function for smoothing data samples; and

FIGS. 8 and 9 illustrate alternate transform structures suitable for calibration in accordance with the present invention.

DETAILED DESCRIPTION

The present invention divides characterization into two component parts: (a) a "standard" characterization for a particular model of printer, which can be generated once "at the factory" of the printer manufacturer or by an after-market supplier of characterizations, and (b) an adaptive part, which adjusts the characterization to the actual characteristics of a specific unit of that model and which can be generated inexpensively by the end user as often as required. The adaptive part makes use of common techniques that fall under the heading of "device calibration". When used to adapt a standard characterization to an actual device, it is referred to here as a "characterization calibration". The standard characterization accounts for the variations in technology or design among printer models; the calibration accounts for the variations over time (for the same unit) or from one unit (of the same model) to the next. Furthermore, the calibration is intrinsically simpler than characterization, in that the former is based on an analysis of the individual colorant channels of the printer taken one at a time, whereas the latter must account for the interactions among the channels.

Conceptually, the standard part is connected to the adaptive part by defining a fixed interface, which is internal to the characterization (viewed as a whole). The standard characterization is embodied in a transformation from the desired visual colors (as specified in a visual color space) to the space of interface code values. The characterization calibration provides a transformation from the interface code values to the command code values for the device.

SYSTEM HARDWARE

A calibration in accordance with the present invention may be implemented on any electronic image processing system. One exemplary system is the Kodak Prophecy Color Publishing System™, a pre-press workstation for the acquisition and processing of high-resolution continuous tone color images for the printing and publishing industry.

FIG. 1 is a block diagram of a Prophecy™ system having a Sun 4™ series computer, with imaging accelerator, a 480x640 pixel interlaced color monitor and a 900x1180 noninterlaced monochrome monitor connected to a variety of inputoutput devices (optionally including a drum scanner, a Photo CD™ digital storage device, PCS **100** imaging station, a Macintosh™ workstation, a color proofer and a PostScript imagesetter). In order to provide consistent color reproduction, each interface to an I/O device is characterized. Printer interfaces can be calibrated in accordance with the present invention.

Of course, a wide variety of other hardware platforms that are suitable for image processing can benefit from the present invention, such as Macintosh and PC type desktop systems.

DEVICE CHARACTERIZATION

A device characterization can be thought of as a nonlinear mapping from a device-independent, visually-based, color space to a nonlinear device-dependent space that yields command codes for a printer such that the printer produces the desired colors.

In a preferred embodiment of the invention, a mapping or transform has a three-data-table representation that regulates a programmed computer used to process an electronic representation of an image. The transformation is physically made up of electronic circuitry operating on electronic signals that represent an image. Calibrations and characterizations may be physically located in a printer or in other processing equipment in the system, or even stored with individual images.

FIGS. 2 and 3 are illustrations of a preferred transform implementation, including details of an input table, a grid table, and an output table. The transform **230** is electronically stored with a header **232**, an optional identification string **234** and tables **236**. The transform has been described in detail in U.S. application Ser. No. 07/832,358, now issued as U.S. Pat. No. 5,208,911, which is incorporated here by reference. Salient points will be reiterated here for convenience to the reader.

The header **232** includes information for regulating the use of the transform, such as identifiers, codes identifying how to interpolate in the tables, size information defining the lengths of particular fields, etc. The optional ID string **234** includes information helpful in identifying the transform, such as a field with ASCII text description.

Most important are the input tables **278**, the grid tables **282**, and the output tables **280**. The tables are grouped according to the color channels **274** of the input color space.

As shown in FIG. **3**, each dimension of the output color space (e.g., C,M,Y) is a separate channel with potentially separate input tables, output table, and grid table. Each input table receives a scalar color value as an input and returns an output value that, in turn, is an entry (address) into one dimension of the grid table. The grid table returns several coefficients which are typically used for tri-linear interpolation to form an intermediate value that, in turn, is an entry into an output table. The output table then returns a final color scalar value that represents a modified color component of a pixel in a transformed image. The transform is applied to the color values of each and every pixel of an input image to generate modified pixels that form a modified output image. Of course, the tables take the physical form of information stored in computer, and the table look-up operations are performed by a computer processor operating in response to program instructions.

This three-table structure provides flexibility for representing a wide variety of transforms as a combination of two non-linear mappings (using the input and output tables) and a tri-linear interpolation process (using the grid tables). Each input table allows for one-dimensional non-linear mapping of an input color scalar into a relatively linear representation of the grid tables. The grid tables allow for an n-dimensional

linear interpolation (where n equals the number of dimensions of a color space, typically three or four). The output table allows for one-dimensional mapping of the interpolated output color scalars into final output color commands.

By way of example, a single three-table transform may operate as follows to modify a scanned original image into a form suitable for printing. In this example, a scanner generates an array of pixels, each having three color components: red, green and blue (a three-dimensional color space referred to as RGB). The printer, however, prints with cyan, magenta, yellow, and black inks (a four dimensional color space referred to as CMYK). The transform of this example converts RGB input values into corresponding CMYK color values. The transformation is accomplished by combining a first transformation that relates the RGB space to a calorimetric reference space, with another transformation that relates the colorimetric reference space to the CMYK output space.

For each pixel, the three RGB components are used to enter the input tables of the first transformation. The pixels are then processed through the grid tables and output tables of the first transformation, at which point they are in a deviceindependent color space, such as u,v,L* (chrominance-luminance). Here, the device-independent color space is perceptually linear so that a numerical increment of color change in any part of the color space results in a perceptually uniform change in color.

The pixels, now in u,v,L* space, then are used to address the input tables of the second transformation. Tri-linear interpolation is performed in the C, M, Y, and K grid tables and the result from each interpolation is applied to the respective C, M, Y, and K output tables. The resulting pixels are in the CMYK color space appropriate for the given output device.

Transforms of this structure can be composed to form a single composite transform that is equivalent to sequential application of a series of individual transforms. In this example, the first transformation relating RGB to u,v,L* is composed with the second transform relating u,v,L* to CMYK in order to generate a composite transform which relates RGB to CMYK. The use of this composite transform allows the image pixels to be processed directly from RGB to CMYK space without the need to compute the u,v,L* representation of each pixel.

In this way, an imaging system can maintain many separate transforms, including input characterizations (for individual input devices), a "toolkit" of device-independent transforms (e.g., for correcting "washed-out" images), and output characterizations. When processing an image, an operator can quickly select, compose and apply groupings of transforms.

Kodak Electronic Printing Systems, Inc. of Billerica, Mass., provides characterizations in such a form for a wide variety of color printer models, such as a QMS™ ColorScript™ **100**. During operation of a typical color station, a user will develop a wide variety of transforms for differing reasons other than ouput characterization. For example, color transforms allow an operator to "brighten" selected colors, change contrast, etc. An image will undergo a number of transformations, including an output characterization transform which attempts to ensure that the physical printer output matches the user's expectation.

A single device characterization for a particular model of printer reduces much of the variation that is otherwise caused by differences in printer models. For example, if a user prints an image on two different models of printers, both prints will have very similar color rendition as long as the image is transformed using the appropriate characterizations.

However, individual units of the same printer model may have slightly different characteristics, and a single printer's characteristics may drift over time. Therefore, using a single "factory" characterization for all units of the same model may still result in variations. These variations may be further reduced by calibrating the characterization as discussed below.

CALIBRATION

Generally, a characterization is made for a device on the assumption that all units of a particular device model behave similarly. The device for which the characterization produces the desired result, without need for calibration, is referred to as the "reference" device. The reference device may have a physical realization or it may be a description of a hypothetical device. The response of the reference device is used to define the aim to which all devices of the given model will be calibrated. For example, one could take a single unit of a printer model, assume that its characteristic is typical, and use its characteristic to define the aim. Alternately, one could take several units and develop an average characteristic which is used to define the aim. Most individual units will have characteristics that are close-to but different-from the reference device. Therefore, when applying the characterization to these individual units without also calibrating to the reference device, slight color errors may still result.

The calibration process measures some aspects of the response of an individual unit and (in a sense) modifies the standard characterization to more precisely reflect the individual unit. The calibration process can also be conceptualized as transforming the unit's individual characteristic to be more like that of the reference device.

The preferred method generates a calibration transform that is represented as a three-table transform having input tables, grid tables, and output tables. The input tables and grid tables are identity mappings (which do not alter data), while the output table maps the device's particular characteristics to the aim. The calibration transform can be sequentially applied with other transforms (including the standard characterization) or can be combined with the standard characterization to produce a calibrated characterization.

FIG. **4** is a flow diagram illustrating steps for calibrating a characterization (in this example, a printer). Generally speaking, a standard "target" image is printed to obtain many different color samples of the printer output. The printed samples are measured (e.g., using a standard densitometer), and the measured values are entered into the imaging system computer. The computer compares the measured color values with the aim values for the target. The computer generates a transform that maps the measured values to the aim values. The transform, in turn, is used to update the printer characterization. Optionally, the process may be repeated using an existing calibration to verify or (if necessary) further improve the accuracy of the characterization.

FIG. **5** is an illustration of a suitable sequence of patches. The target sequence has a series of 16 rows. Rows **1**, **5**, **9** and **13** each have 18 cyan color patches. Each patch has a distinct density. Rows **2**, **6**, **10** and **14** have magenta patches; rows **3**, **7**, **11** and **15** have yellow patches; and rows **4**, **8**, **12** and **18** have black patches. For each color, patches that are close in density are located separately on the target. Patches may be arranged in different order, or on separate pages with other images.

The particular number and size of patches may vary. Typical patches are about 0.25 to 0.5 inches square with about 36–72 nonequally spaced steps (in device code value).

There should be one set for each colorant, e.g., 3 for CMY, 4 for CMYK. It is customary to measure a colorant with a complementary filter when making measurements of the target with a densitometer. For example, cyan is measured with a red densitometer filter. By convention, black is measured with a green filter. The target may also be measured with a spectrophotometric device. Spectral data can be reduced mathematically to a density by integrating over wavelength using known techniques. On a three-colorant device, all colorants can be measured simultaneously by printing various levels of gray using equal amounts (in device codes) of the three colorants.

Some spatial non-linearities of printers that might otherwise distort target colors can be reduced by surrounding the patches with a noise pattern consisting of equal numbers of black and white pixels set alternately to the minimum and maximum code values. Thermal printers, for example, often have latency effects which cause areas on different parts of a page to have different density, even if printed with the same code value. This can be caused by residual heat in the print head. The alternating background pattern keeps the print head at a roughly constant temperature.

FIG. 6 is an illustration of a data input screen for manually entering density data for a printed target. After measuring the density of each color patch, the operator enters the measurements in a spreadsheet-like form. With this information, a software library routine analyzes the measurements and generates a calibration transform in a manner that will be discussed more fully below.

SMOOTHING

The measured values are a discrete set of points that may be corrupted by noise. In order to reduce the impact of noise and quantization, the preferred embodiment fits a B-spline curve to the measured data. The resulting B-spline is a weighted sum of predetermined B-spline basis functions. The weights are chosen to minimize a mean square error between the function and the data samples while also yielding a monotonic function.

Each basis is a piecewise polynomial having non-zero values over a portion of the code value range. That is, the non-zero range of each basis function is divided into a number of polynomial segments. For each segment, the basis is equal to a single cubic polynomial. Adjacent segments may be represented by a different polynomial. The polynomial coefficients vary for each segment. The basis functions are continuous at the knots (segment boundaries) and provide an overall shape that is gaussian-like (bell shaped). Different basis functions peak in different parts of the code value range as shown in FIG. 7. The number of basis functions and the number of knots may vary according to the complexity of the behavior of the printer characteristic, and 8–24 basis functions are contemplated as typical. Background on use of spline functions can be found in C. DeBoor, A Practical Guide to Splines, Springer Verlag, N.Y., 1978.

It is desirable that the mean square error, representing the difference between the smoothing function and the measured data, have an equivalence to the visual perceptibility of this difference. Therefore, the preferred embodiment of the algorithm fits the curve using a metric which is proportional to the measured light intensity raised to the ⅓ power. This results in a metric which is more visually uniform than either density or the intensity itself.

It is also important that the resulting smoothing function be monotonic in order that the relationship between device command value and measured device response be invertible. In the preferred embodiment, the initial B-spline function is checked for monotonicity. The coefficients which describe the spline function are those which minimize the error metric or cost function described above. If the coefficients do not describe a monotonic function they must be altered and this, in turn, implies an increase in the error metric. Therefore, if the function is not monotonic, the vector space containing the coefficients is searched in order to find a solution which is both monotonic and has a relatively small value for the cost function. It is thus an optimization problem and software methods for solution are thoroughly described in the literature. See, for example, P. E. Gill and W. Murray, ed., Numercial Methods for Constrained Optimization, Academic Press, London, 1974.

Of course, the smoothing function need not be a B-spline. It is sufficient that the function be continuous and monotonic over the code value range. Nor is it necessary to fit the data to the function using a mean squared error cost function. Depending on the complexity of the characteristic and the accuracy required for each printer, other methods for fitting data to the function may be used.

In addition to smoothing, curve fitting the data reduces the number of color patches used. By printing a limited number patches (e.g., one patch for every four steps in code value) and by fitting a curve to the data, responses for intermediate code values may be approximated by evaluating the function. This is more accurate than linear interpolation. Thus, if the number of sample points is so large as to equal the number of code values in the printer's range and if the amount of noise is small, a curve-fit step may not be required at all.

After smoothing the measured data, a calibration transform is constructed having an input table, a grid table and an output table. The input and grid tables are identity transforms. The output table is, in substance, a look-up table that maps a first set of code values into a second set of code values according to the difference between the measured device characteristic (as represented by the smoothing function) and the aim for which the characterization was developed.

Considering a single channel as an example, the original characterization may have been based on an aim in which an interface code value of 100 generated a density of 0.45 for its cyan channel, but the response of an actual device to a code value of 100 gives a density of 0.50. Assume that the smooth curve representing the cyan device response indicates that a command value of 105 is required to achieve a density of 0.45 on this device. A calibration for this printer would map a cyan interface code value of 100 to a device code value of 105.

In this example, the characterization maps a color in u,v,L* space to a color in a CMYK space. Conceptually, the characterization transform is followed by a second transform: the calibration. The calibration maps the CMYK code values appropriate for the reference device into the CMYK code values appropriate for the user's device. As will be seen below, equivalent implementations result in a more computationally efficient mapping.

COMPOSITION OF CHARACTERIZATION AND CALIBRATION TRANSFORMS

An important variation of the present invention is the composition of a characterization and a calibration into a single, composite transformation, rather than a cascade of multiple transforms.

In the cascaded example above, a u,v,L* color was first transformed to an interface CMYK value (by the standard characterization) and then to a CMYK code value tuned to account for deviations from the reference (by the

calibration). Instead, the characterization output table can be replaced by a table that produces tuned CMYK values without need of a second transformation. This is achieved by composing the two transforms in a manner taught in Ser. No. 07/832,358.

This three-table structure also allows for convenient composition of calibrated characterizations with other transforms into a single composite transform. Salient advantages of the composition process are: 1) application of a composite transform yields substantially the same result as sequential application of the individual transforms; and 2) a composite transform executes faster than the sequential application of the individual transforms. Thus, a user can further modify the calibrated characterization according to any of a wide variety of requirements, such as gamut mapping, color adjustment, tone correction, etc. Similarly, a previously modified transformation can be calibrated.

OTHER EXAMPLES OF CHARACTERIZATION CALIBRATION

Calibration of a characterization does not pertain exclusively to a three-table transform of the kind described above. The calibration of a characterization can be applied to any number of methods used to represent the characterization of a device. For example, a very simplistic characterization could be represented by a simple matrix, as shown in FIG. 8. Here, a matrix operation is a transform from colors represented in an input color space (X, Y, Z) into values represented in a space of colorants used for printing (CMYK). The channel-independent lookup is a transformation that maps one set of CMYK values to a new set according to an aim for the particular model or type of printer. In this case the printer is first calibrated to a desired aim using the channel-independent, one-dimensional transforms.

With the printer in this known state, a simple matrix can be derived to relate data in an input color space, such as XYZ, to the calibrated aim state of the printer. Then as the response of the printer drifts in time it can be corrected back to the aim state in which it was characterized by modifying the channel lookup or applying a further mapping.

Another example of a characterization which could be calibrated using this technique would be a PostScript® level 2 color rendering dictionary as described in the 2nd edition of the PostScript® Language Reference Manual. In the PostScript® level 2 environment, there are number places where a channel independent process could be implemented prior to characterization. One of these is in the CIE based color rendering dictionary. The output processing path for PostScript® level 2 color rendering dictionaries contains the elements shown in FIG. 9.

In this example, PQR represented a tone-adjustment and white paint transform that maps an input of 3 color components (X, Y, Z) into another color (X', Y', Z') of the same color space. LMNABC represents a color transform from (X', Y', Z') color space to a space represented by a different set of base colors (A, B, C). The Render Table represents a transformation that maps colors from the (ABC) color space into colorants used by the printing device (CMYK).

At the end of this processing chain is a channel-independent operation (called the "T" procedure) which was designed to transform the interpolated, encoded components to device color component values. This T table could also be used to set the output device to a desired aim state. In the process of building the final rendering dictionary, the two aspects of the T table can be composed together to form a single table that does both the transformation of the interpolated, encoded components and the setting the device to a desired aim response. As the response of the device changes with time, the output color rendering dictionary could be updated with new T tables that put the device back on the desired aim.

In summary, device characterization that takes into account many aspects of the device (screening, dot gain, ink spectral reflectance . . .) tends to require expensive, precision instrumentation not typically available to most end-users of a color system. Thus, a "factory" characterization for a particular model printer tends to be generated once "at the factory" of the printer manufacturer or by an after-market supplier of characterizations. However, the response of individual units of the same printer model may differ, and the response of a single printer may drift over time. Therefore, using a single "factory" characterization for all units of the same model may still result in variations. Using the method of the present invention, the user's system can be improved economically by providing a calibration capability which may be merged with the characterization, tuning the characterization for a specific user's device.

Another advantage of a calibration method as described above is that calibration can be completed independently of other parameters (such as the spectral reflectance of the inks). Colorant spectral reflectance is typically not recalibrated without use of expensive equipment unavailable to the average end-user. Thus, the end-user's system can be improved economically by providing a calibration capability which may be merged with the characterization, tuning the characterization for a specific user's device.

After learning of the embodiments described above, people practicing in this art will be able to make variations that fall within the spirit and scope of the invention. The embodiments described above are exemplary but not intended to limit the scope of the invention as defined by the following claims.

What is claimed is:

1. A method for adapting a color printer characterization, comprising:

defining a reference printer from among a family of printers and having a reference aim response;

characterizing the reference printer across channels of the reference printer to produce a reference characterization;

determining a calibration for each printer of the family against the reference aim response using each channel separately by:

printing a sequence of patches;

measuring responses of printed colors from the printed sequence of patches; and

generating a calibration relationship between the measured responses and the reference aim response; and

modifying the reference characterization using the calibration to produce an adapted characterization for each printer of the family by incorporating the calibration relationship into the characterization transform definition to form the adapted printer characterization;

wherein said printer characterization includes

1) input table data,

2) grid table data,

3) output table data,

4) size data specifying a size of one of the grid table's dimensions, and

5) identification data identifying the characterization as a transform definition.

2. The method of claim 1 wherein the calibration incorporation step includes a step of composing a calibration function with a characterization function.

3. The method of claim 1 wherein the calibration incorporation step includes a step of modifying a channel-independent table.

4. The method of claim 1 wherein the calibration incorporation step includes a step of replacing a channel-independent table.

5. The method of claim 1 wherein the calibration relationship generating step includes a step of fitting a curve to measured responses for a plurality of printed colors.

6. The method of claim 1 wherein the calibration relationship generating step includes a step of fitting a curve represented as a combination of basis functions to measured responses for a plurality of printed colors.

7. The method of claim 1 wherein the calibration relationship generating step includes a step of fitting a curve represented as a combination of B-spline curves to measured responses for a plurality of printed colors.

8. The method of claim 1 wherein the printing step includes a step of printing a target having a plurality of color patches.

9. The method of claim 1 wherein the calibration relationship generating step includes steps of:

fitting a curve represented as combination of basis functions to measured responses for a plurality of printed colors; and

evaluating the curve for colors other than those to which the curve was fit.

10. A method for adapting a printer characterization transform representing a color printer characterization, said printer characterization transform generating output values in response to input values, said adapting method comprising:

defining a reference printer from among a family of printers and having a reference aim response;

characterizing the reference printer across channels of the reference printer to produce a reference characterization;

determining a calibration for each printer of the family against the reference aim response using each channel separately by:

printing a target image having multiple target patches, differing target patches commanded to have different color densities;

measuring color densities of printed target patches; and

generating a calibration transform having a one-dimensional table for each color channel, each table incorporating a relationship between the aim response and measured color densities; and

modifying the reference characterization using the calibration to produce an adapted characterization for each printer of the family by composing the calibration transform with the printer characterization transform to generate a single transform;

wherein said composing step includes steps of:

1) transforming printer characterization output values in accordance with said calibration transform to generate modified output values; and

2) generating a single transform relating printer characterization input values to said modified output values, thereby adapting the printer characterization.

11. The method of claim 10 wherein the calibration transform generating step includes a step of fitting a curve to measured responses for a plurality of colors.

12. The method of claim 10 wherein the calibration transform generating step includes a step of fitting a curve represented as a combination of basis functions to measured responses for a plurality of colors.

13. The method of claim 10 wherein the calibration transform generating step includes a step of fitting a curve represented as a combination of B-spline curves to measured responses for a plurality of colors.

14. The method of claim 10 wherein the calibration transform generating step includes a step of fitting a curve represented as a combination of piecewise polynomials to measured responses for a plurality of colors.

15. The method of claim 10 wherein the calibration transform generating step includes steps of:

fitting a curve to measured responses for a plurality of colors; and

evaluating the curve for colors other than those to which the curve was fit.

16. A system, comprising:

means for defining a reference printer from among a family of printers and having a reference aim response;

means for characterizing the reference printer across channels of the reference printer to produce a reference characterization;

an input for receiving an electronic representation of an image;

processing means for processing values of the electronic representation of the image;

an adapted printer generating a hardcopy of the electronic representation of the image, said adapted printer having a relationship between electronic command values and print density;

a plurality of transform definitions in a shared format;

a printer characterization and an adapted characterization, said printer characterization and said adapted characterization having the format of a transform definition and generating output electronic command values from input electronic command values prior to printing; and

means for composing the characterization transform with a calibration transform to calibrate said printer characterization to produce the adapted characterization;

wherein said composing means includes:

1) means for transforming printer characterization output command values in accordance with a calibration transform to generate modified output command values for the adapted characterization, wherein said means for transforming includes:

means for determining a calibration for the adapted printer against the reference aim response of the reference printer using each channel separately; and

means for modifying said printer characterization using the calibration to produce said adapted characterization for said adapted printer; and

2) means for generating a single transform relating adapted characterization input command values to said modified output values.

17. The system of claim 16 wherein the characterization calibration means includes means for generating a calibration transform.

18. The system of claim 17 further including means for sequentially applying the characterization and the calibration transform to an image.

19. The system of claim 16 wherein the characterization calibration means includes means for fitting a curve to measured responses for a plurality of colors.

20. The system of claim 16 wherein the characterization calibration means includes:

means for fitting a curve to measured responses for a plurality of colors; and

means for generating a calibration transform by evaluating the curve.

21. A method of adapting a color printer characterization, comprising:

defining a reference first printer having a reference aim response;

characterizing the first printer across channels of the reference printer to produce a reference characterization;

determining a calibration of a second printer against the reference aim response using each channel separately by:

printing a sequence of patches;

measuring responses of the patches; and

generating a calibration relationship between the measured responses and the reference aim response; and

incorporating the calibration relationship into a characterization transform definition of the characterization modifying the reference characterization using the calibration to produce an adapted characterization for the second printer.

* * * * *

US006535293B1

(12) **United States Patent**
Mitsuhashi

(10) **Patent No.:** **US 6,535,293 B1**
(45) **Date of Patent:** **Mar. 18, 2003**

(54) **PRINTING SYSTEM, PRINTING CONTROL METHOD, DATA PROCESSING APPARATUS AND METHOD, AND STORAGE MEDIUM THEREFOR**

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(73) Assignee: **Canon Kabushiki Kaisha**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/298,962**

(22) Filed: **Apr. 26, 1999**

(30) **Foreign Application Priority Data**

Apr. 28, 1998 (JP) 10-118739

(51) **Int. Cl.**[7] **G06K 15/00**

(52) **U.S. Cl.** **358/1.13**; 358/1.18

(58) **Field of Search** 358/1.1, 1.3, 1.4, 358/1.6, 1.13, 1.16, 1.17, 1.18, 538, 540, 450, 453; 382/173, 175, 176, 180, 195, 282, 283, 284

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,974,171 A * 11/1990 Yeh et al. 358/1.13
6,005,680 A * 12/1999 Luther et al. 358/2.1

* cited by examiner

Primary Examiner—Arthur G. Evans
(74) *Attorney, Agent, or Firm*—Fitzpatrick, Cella, Harper & Scinto

(57) **ABSTRACT**

Print information to be printed by a printing apparatus is generated in response to a print request command, and coordinate information representing a plotting area of a generated print object is registered in a registration area. When a character string is printed, the registered coordinate information is compared with character-string print position information and whether or not there is overlap is determined. The type of processing for printing the character string is switched based upon the results of the determination, and it is possible to set a print processing mode that is optimum for a print object.

30 Claims, 22 Drawing Sheets

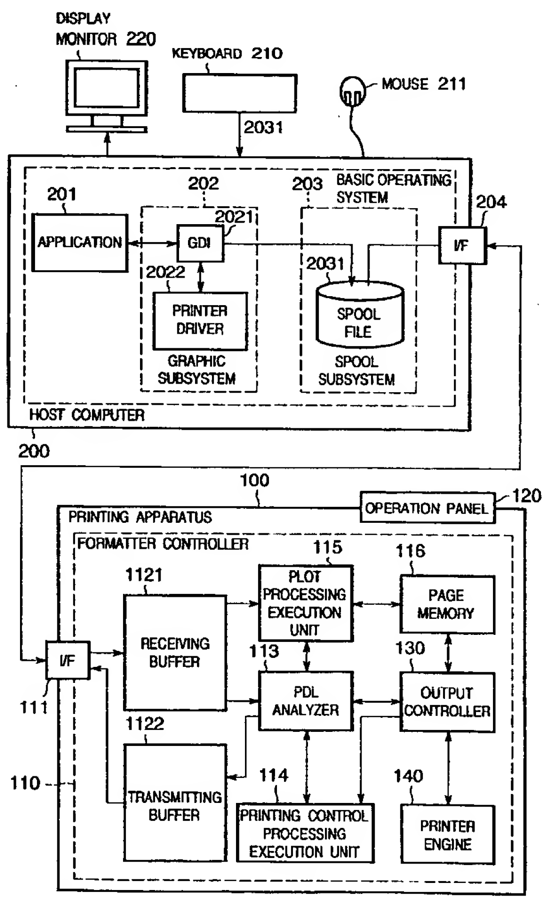


FIG. 1

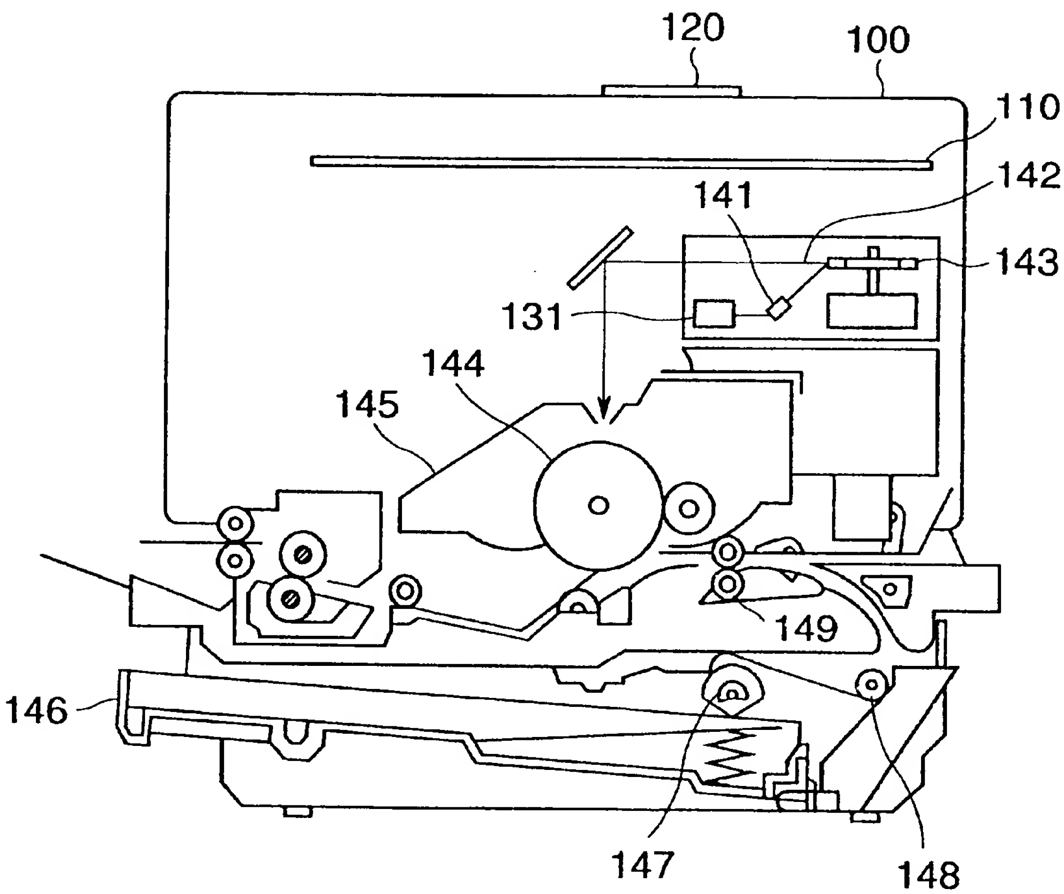
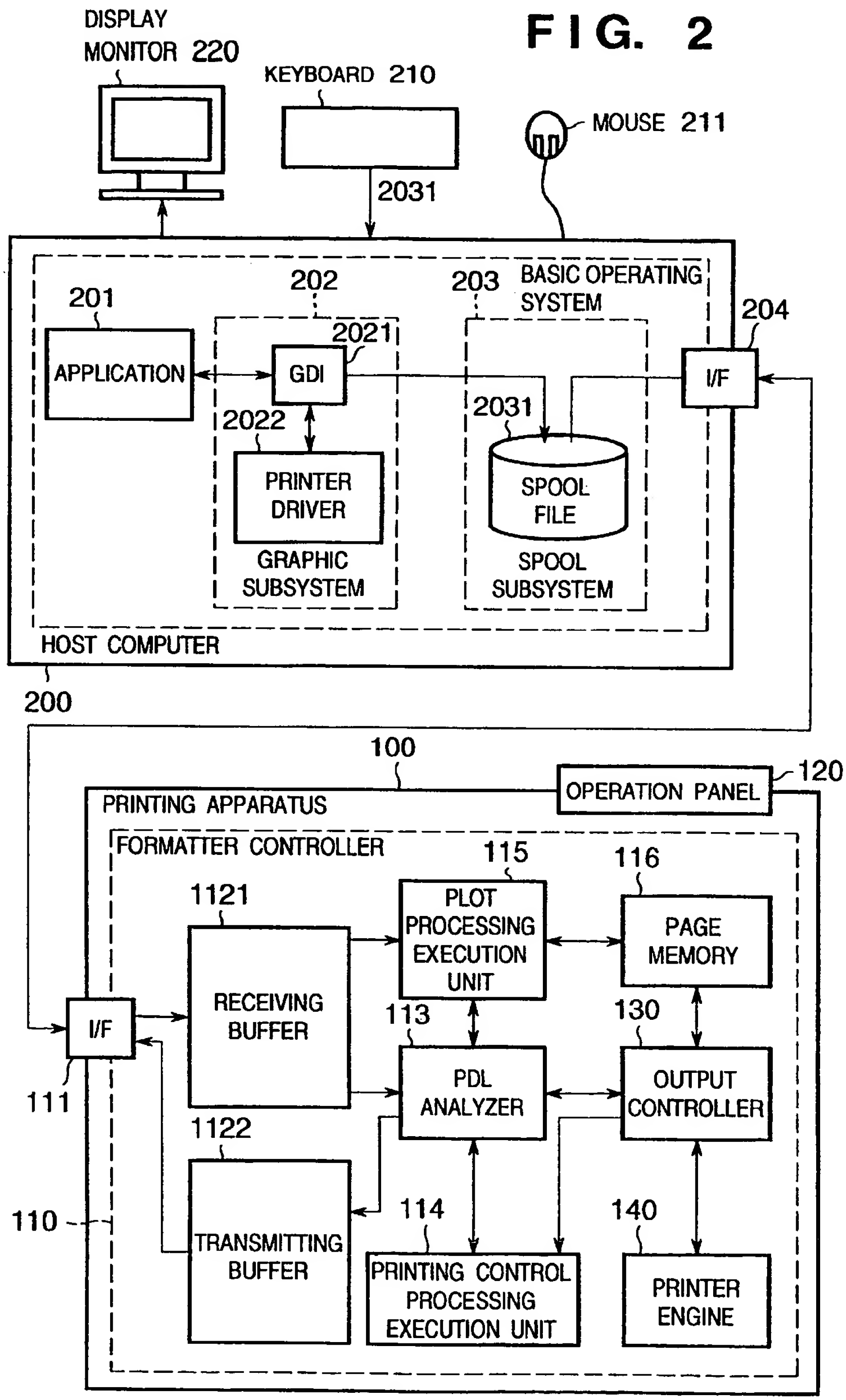


FIG. 2


DISPLAY MONITOR 220
KEYBOARD 210
MOUSE 211
2031
BASIC OPERATING SYSTEM
201
202
203
204
2021
APPLICATION
GDI
I/F
2022
2031
PRINTER DRIVER
SPOOL FILE
GRAPHIC SUBSYSTEM
SPOOL SUBSYSTEM
HOST COMPUTER
200
100
120
OPERATION PANEL
PRINTING APPARATUS
FORMATTER CONTROLLER
115
116
1121
PLOT PROCESSING EXECUTION UNIT
PAGE MEMORY
RECEIVING BUFFER
I/F
113
130
PDL ANALYZER
OUTPUT CONTROLLER
111
1122
110
114
140
TRANSMITTING BUFFER
PRINTING CONTROL PROCESSING EXECUTION UNIT
PRINTER ENGINE

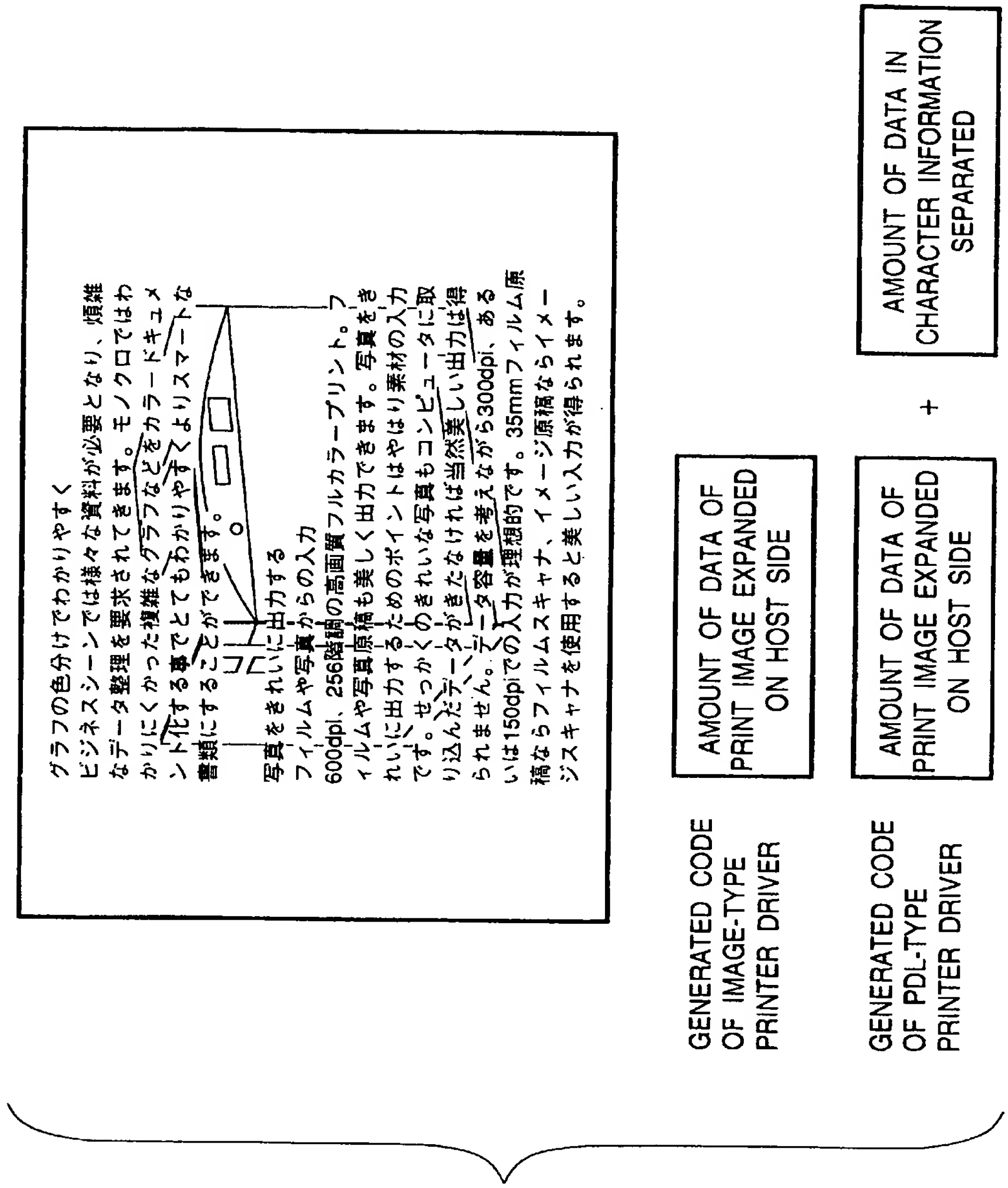

GENERATED CODE OF IMAGE-TYPE PRINTER DRIVER
AMOUNT OF DATA OF PRINT IMAGE EXPANDED ON HOST SIDE
GENERATED CODE OF PDL-TYPE PRINTER DRIVER
AMOUNT OF DATA OF PRINT IMAGE EXPANDED ON HOST SIDE
+
AMOUNT OF DATA IN CHARACTER INFORMATION SEPARATED

FIG. 3

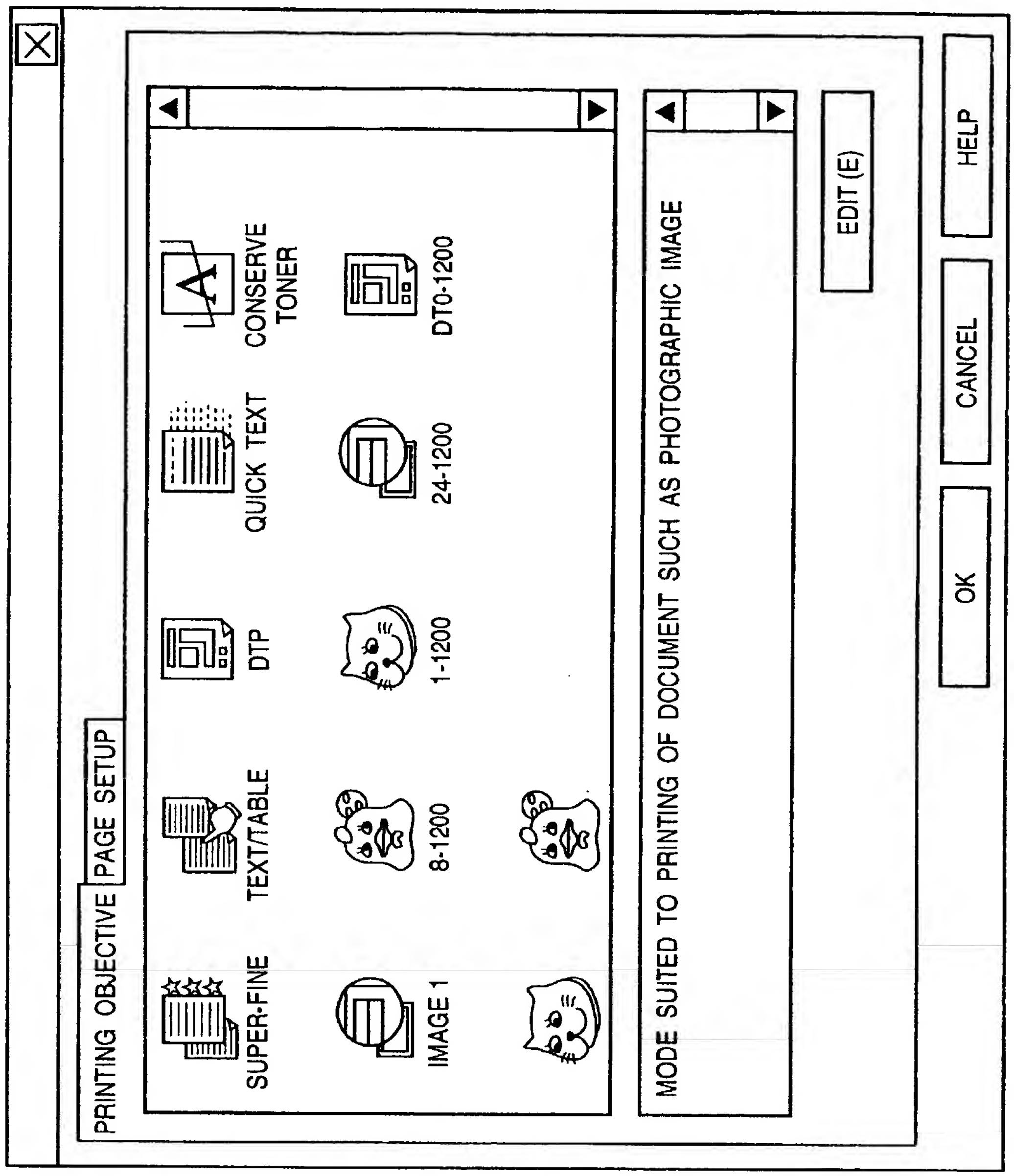
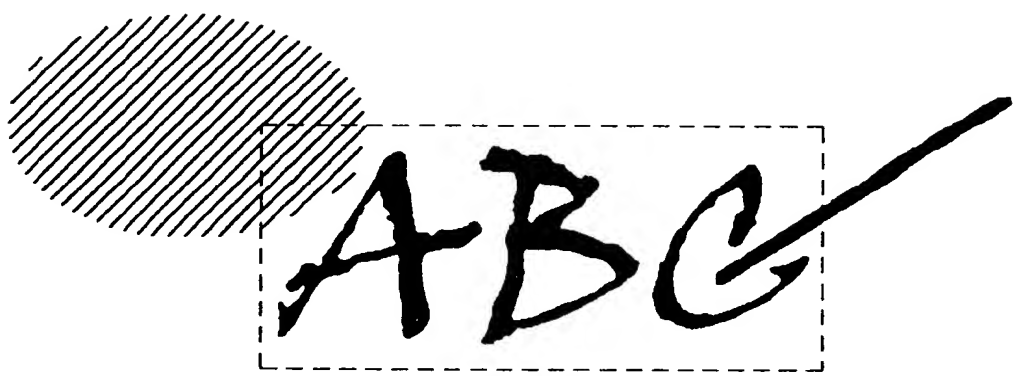

PRINTING OBJECTIVE
PAGE SETUP
SUPER-FINE
TEXT/TABLE
DTP
QUICK TEXT
CONSERVE TONER
IMAGE 1
8-1200
1-1200
24-1200
DT0-1200
MODE SUITED TO PRINTING OF DOCUMENT SUCH AS PHOTOGRAPHIC IMAGE
EDIT (E)
OK
CANCEL
HELP

FIG. 4

FIG. 5



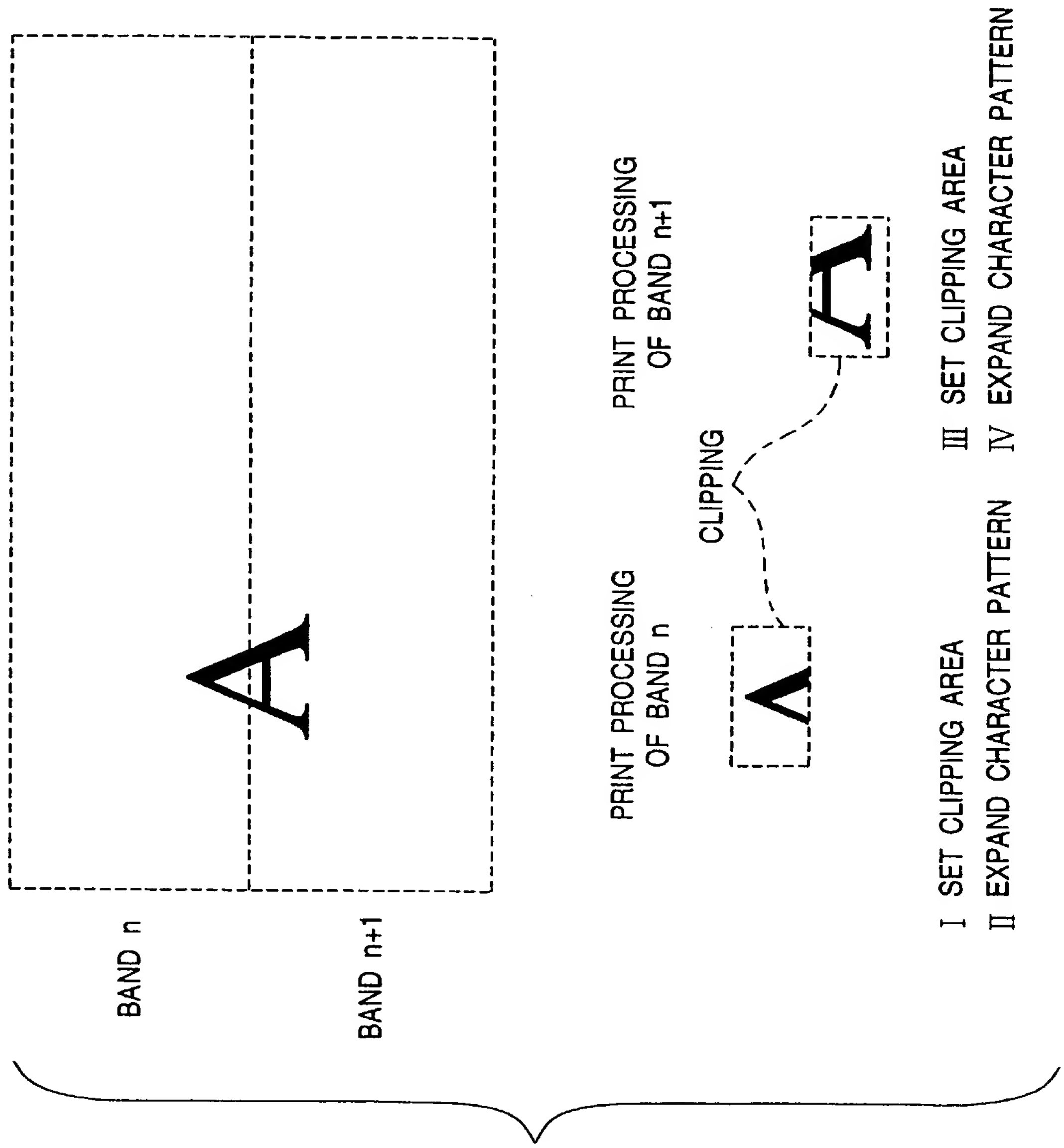

BAND n
BAND n+1
PRINT PROCESSING OF BAND n
CLIPPING
PRINT PROCESSING OF BAND n+1
I SET CLIPPING AREA
II EXPAND CHARACTER PATTERN
III SET CLIPPING AREA
IV EXPAND CHARACTER PATTERN

FIG. 6

FIG. 7A

FINAL PRINT IMAGE OF BAND n

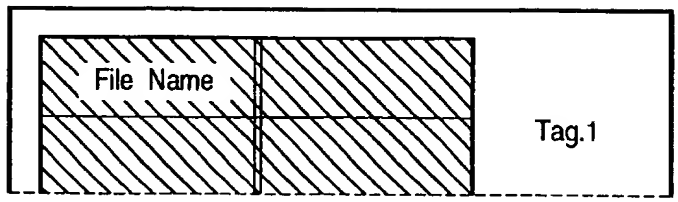


FIG. 7B

SCHEMATIC VIEW SHOWING PROCESS FOR GENERATING PRINT IMAGE OF BAND n

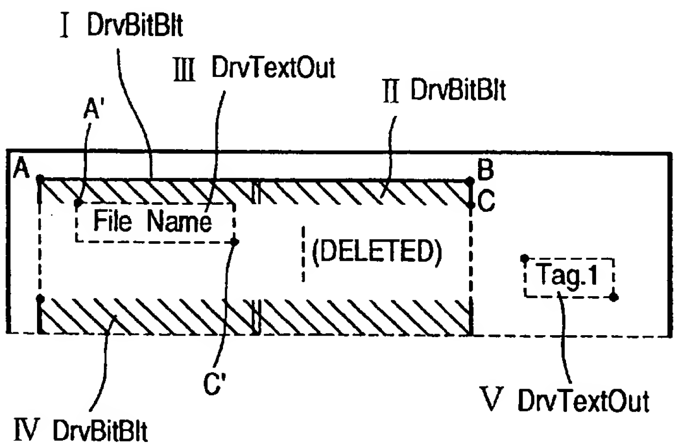


FIG. 8

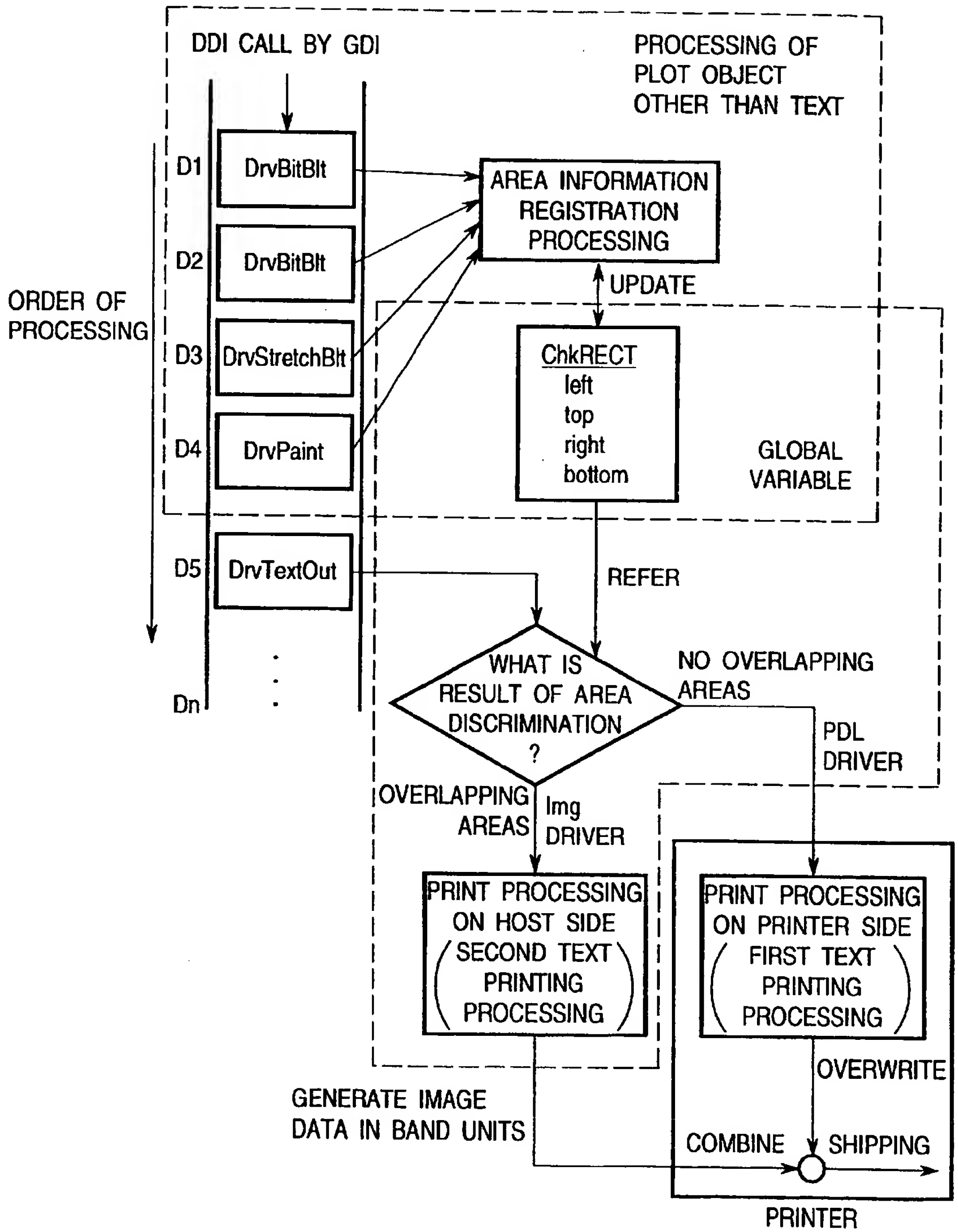

DDI CALL BY GDI
PROCESSING OF PLOT OBJECT OTHER THAN TEXT
D1
DrvBitBlt
D2
DrvBitBlt
D3
DrvStretchBlt
D4
DrvPaint
D5
DrvTextOut
Dn
ORDER OF PROCESSING
AREA INFORMATION REGISTRATION PROCESSING
UPDATE
ChkRECT
left
top
right
bottom
GLOBAL VARIABLE
REFER
WHAT IS RESULT OF AREA DISCRIMINATION ?
NO OVERLAPPING AREAS
PDL DRIVER
OVERLAPPING AREAS
Img DRIVER
PRINT PROCESSING ON HOST SIDE (SECOND TEXT PRINTING PROCESSING)
PRINT PROCESSING ON PRINTER SIDE (FIRST TEXT PRINTING PROCESSING)
OVERWRITE
GENERATE IMAGE DATA IN BAND UNITS
COMBINE
SHIPPING
PRINTER

FIG. 9

```
/*###AREA REGISTRATION PROCESSING###*/
ChkRECT. left   =min(TrgRECT.left    , ChkRECT. left   );
ChkRECT. top    =min(TrgRECT.top     , ChkRECT. top    );
ChkRECT. right  =max(TrgRECT.right   , ChkRECT. right  );
ChkRECT. bottom=max(TrgRECT.bottom , ChkRECT. bottom );
```

FIG. 10

```
/*###AREA DISCRIMINATION PROCESSING###*/
BOOL ChkRECT( . . . ){
   BOOL bNonOverlap=FALSE;
   if(!((ChkRECT.left==ChkRECT.right)||(ChkRECT.top==ChkRECT.bottom))){
    if(pco->rclBounds.right<ChkRECT.left)
    ||(ChkRECT.right<pco->rclBounds.left)
    ||(pco->rclBounds.bottom <ChkRECT.top)
    ||(ChkRECT.bottom<pco->rclBounds.top))
   bNonOverlap=TRUE;
  }
  return(bNonOverlap);
}
```

FIG. 11

```
/*###TEXT PRINTING DDI###*/
BOOL DrvTextOut( . . . . . ){
        :
    (DELETED)
        :
   if(bNonOverlap==TRUE){
    ImgTextOut( . . . . . );
   }
   else{
    PDLTextOut( . . . . . );
   }
}
```

FIG. 12

A

B

特徴的な機能

●製本印刷(面付け両面印刷)が可能な
Page Composer機能

両面印刷ユニットを装着したプリンタでは、1枚の用紙の両面に2ページずつ印刷し、出力された用紙を指定した枚数分ごとにまとめて二つ折りにすると本の体裁になる製本印刷が可能です。綴じ代の調整や拡大、縮小の調整を行うこともできます。

●プレビューで印刷結果を確認しながら
行える用紙設定

印刷するときの様々な用紙設定は常にドライバプロパティ画面の左上のプレビュー画面に表示されています。
制作時の原稿サイズ、印刷時の用紙サイズ、1%刻みの拡大・縮小(50%～200%)や2ページ/4ページを1枚の用紙に印刷する設定などもプレビュー画面を見ながら簡単に設定することができます。

FIG. 13

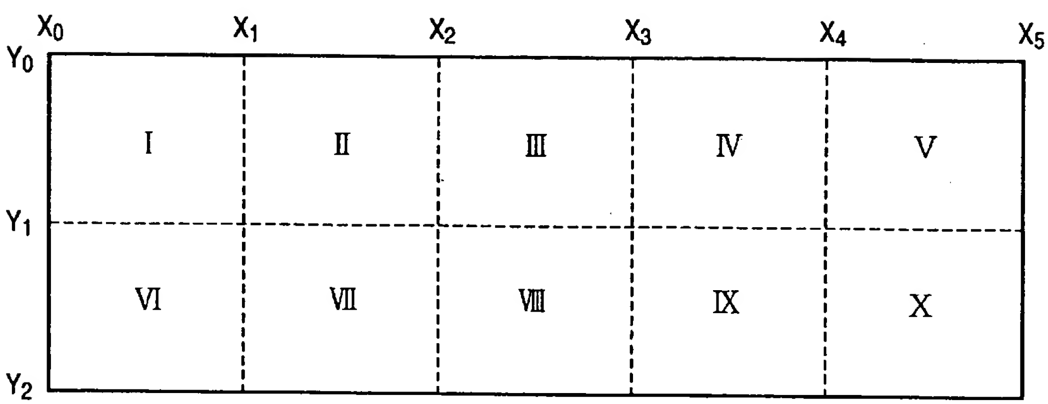


FIG. 14

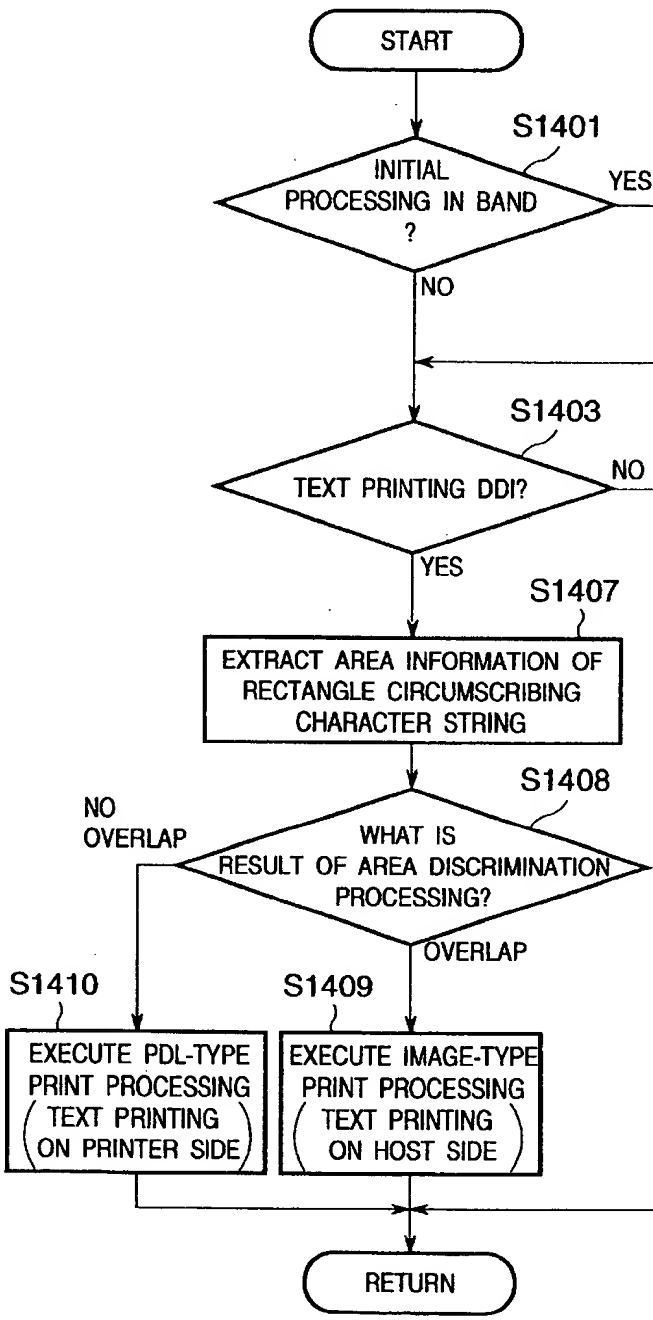

START
S1401
INITIAL PROCESSING IN BAND ?
YES
NO
S1402
INITIALIZE ARRAY FOR SUBAREA MANAGEMENT
S1403
TEXT PRINTING DDI?
NO
YES
S1404
EXTRACT AREA INFORMATION OF PLOT OBJECT
S1405
EXECUTE AREA REGISTRATION PROCESSING
S1406
TEXT PRINTING DDI?
S1407
EXTRACT AREA INFORMATION OF RECTANGLE CIRCUMSCRIBING CHARACTER STRING
S1408
WHAT IS RESULT OF AREA DISCRIMINATION PROCESSING?
NO OVERLAP
OVERLAP
S1410
EXECUTE PDL-TYPE PRINT PROCESSING (TEXT PRINTING ON PRINTER SIDE)
S1409
EXECUTE IMAGE-TYPE PRINT PROCESSING (TEXT PRINTING ON HOST SIDE)
RETURN

FIG. 15

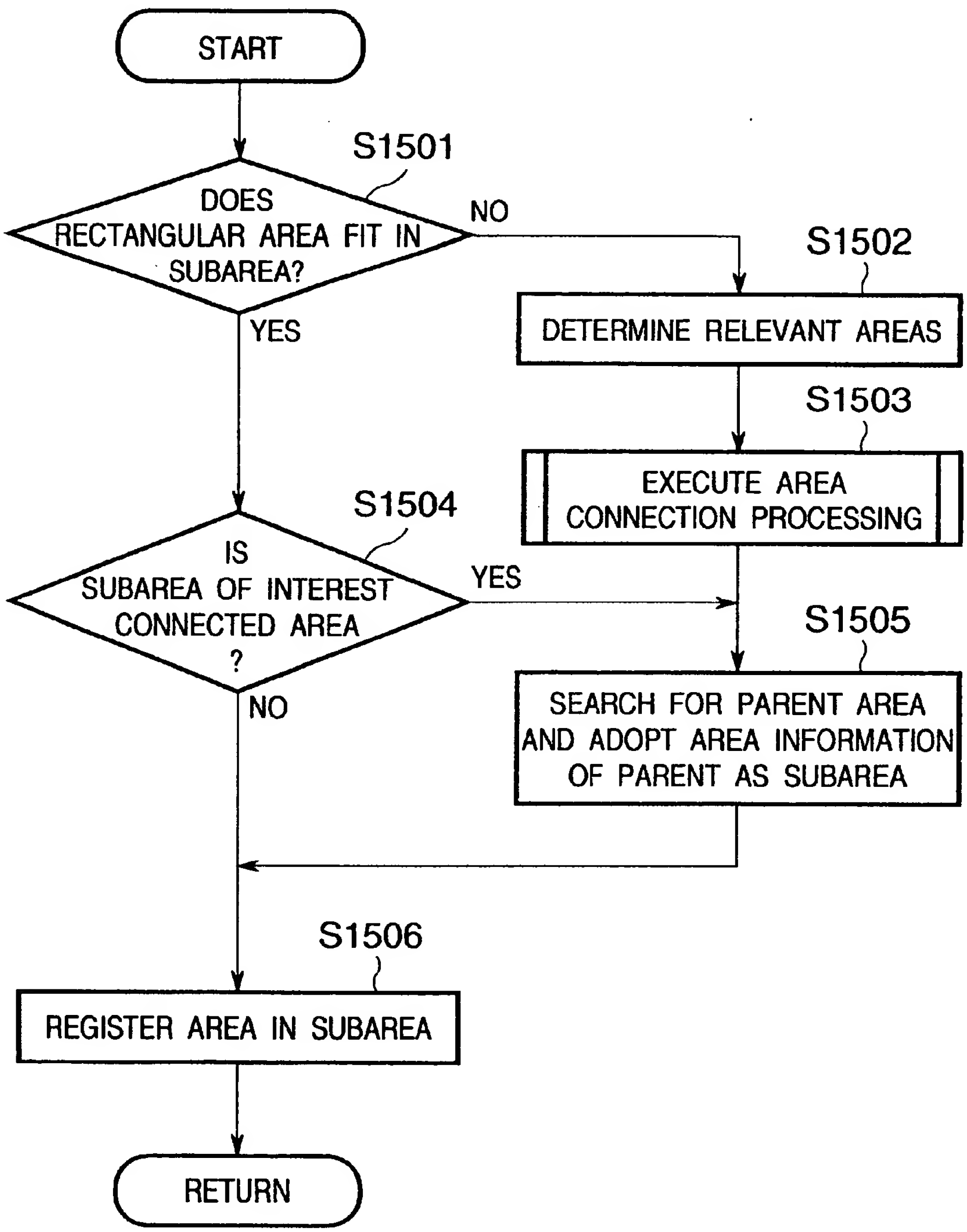

START
S1501
DOES RECTANGULAR AREA FIT IN SUBAREA?
NO
YES
S1502
DETERMINE RELEVANT AREAS
S1503
EXECUTE AREA CONNECTION PROCESSING
S1504
IS SUBAREA OF INTEREST CONNECTED AREA ?
YES
NO
S1505
SEARCH FOR PARENT AREA AND ADOPT AREA INFORMATION OF PARENT AS SUBAREA
S1506
REGISTER AREA IN SUBAREA
RETURN

FIG. 16

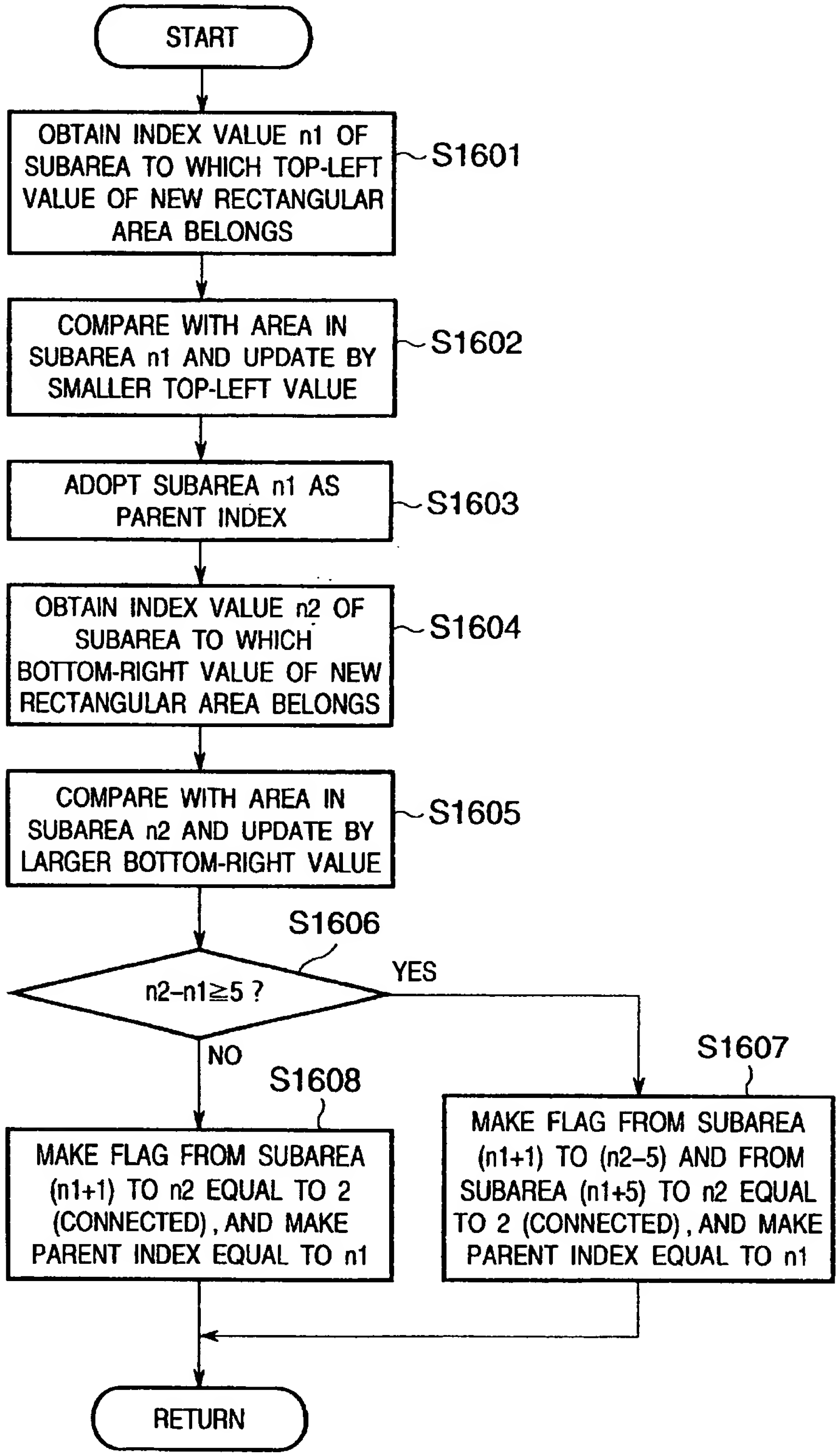
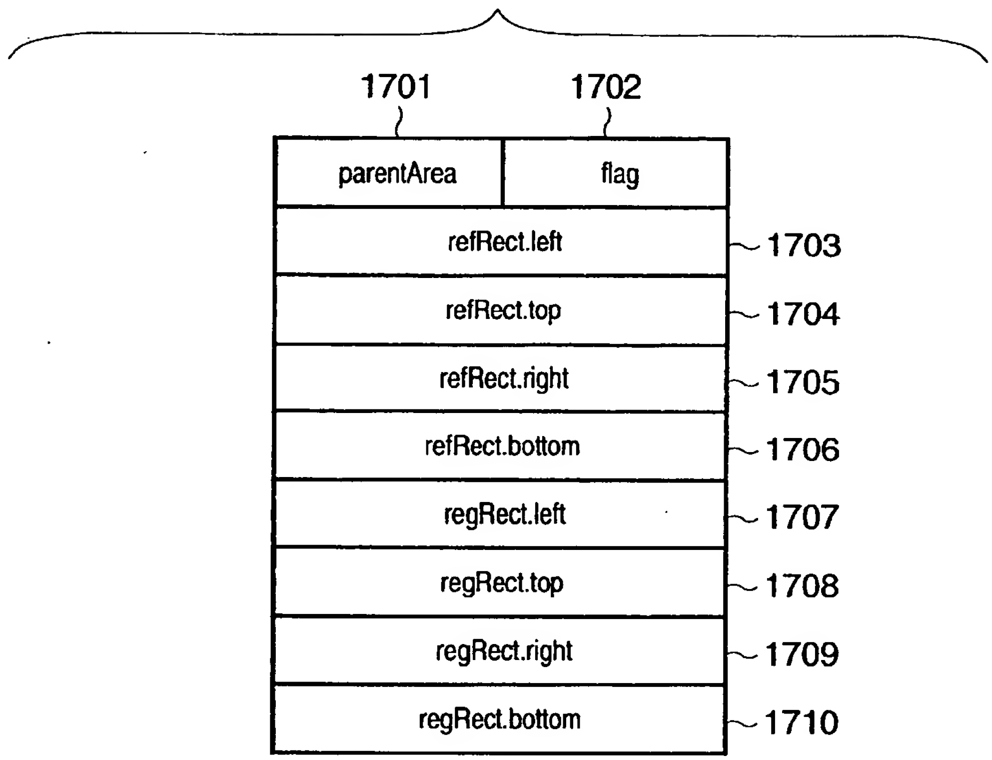

START
OBTAIN INDEX VALUE n1 OF SUBAREA TO WHICH TOP-LEFT VALUE OF NEW RECTANGULAR AREA BELONGS
S1601
COMPARE WITH AREA IN SUBAREA n1 AND UPDATE BY SMALLER TOP-LEFT VALUE
S1602
ADOPT SUBAREA n1 AS PARENT INDEX
S1603
OBTAIN INDEX VALUE n2 OF SUBAREA TO WHICH BOTTOM-RIGHT VALUE OF NEW RECTANGULAR AREA BELONGS
S1604
COMPARE WITH AREA IN SUBAREA n2 AND UPDATE BY LARGER BOTTOM-RIGHT VALUE
S1605
S1606
n2−n1≧5 ?
YES
NO
S1607
MAKE FLAG FROM SUBAREA (n1+1) TO (n2−5) AND FROM SUBAREA (n1+5) TO n2 EQUAL TO 2 (CONNECTED), AND MAKE PARENT INDEX EQUAL TO n1
S1608
MAKE FLAG FROM SUBAREA (n1+1) TO n2 EQUAL TO 2 (CONNECTED), AND MAKE PARENT INDEX EQUAL TO n1
RETURN

FIG. 17




```
typedef struct _SUBAREA
{
  short   flag ;          //0:UNREGISTERED, 1:INDEPENDENT, 2:CONNECTED
  short   parentArea ;    //INDEX OF SUBAREA WHICH BECOMES PARENT WHEN
                           CONNECTION IS MADE
  RECT refRect ;          //MANAGEMENT AREA OF SUBAREA
  RECT regRect ;          //REGISTRATION AREA OF BACKGROUND AREA INFORMATION
} SUBAREA
```

FIG. 18

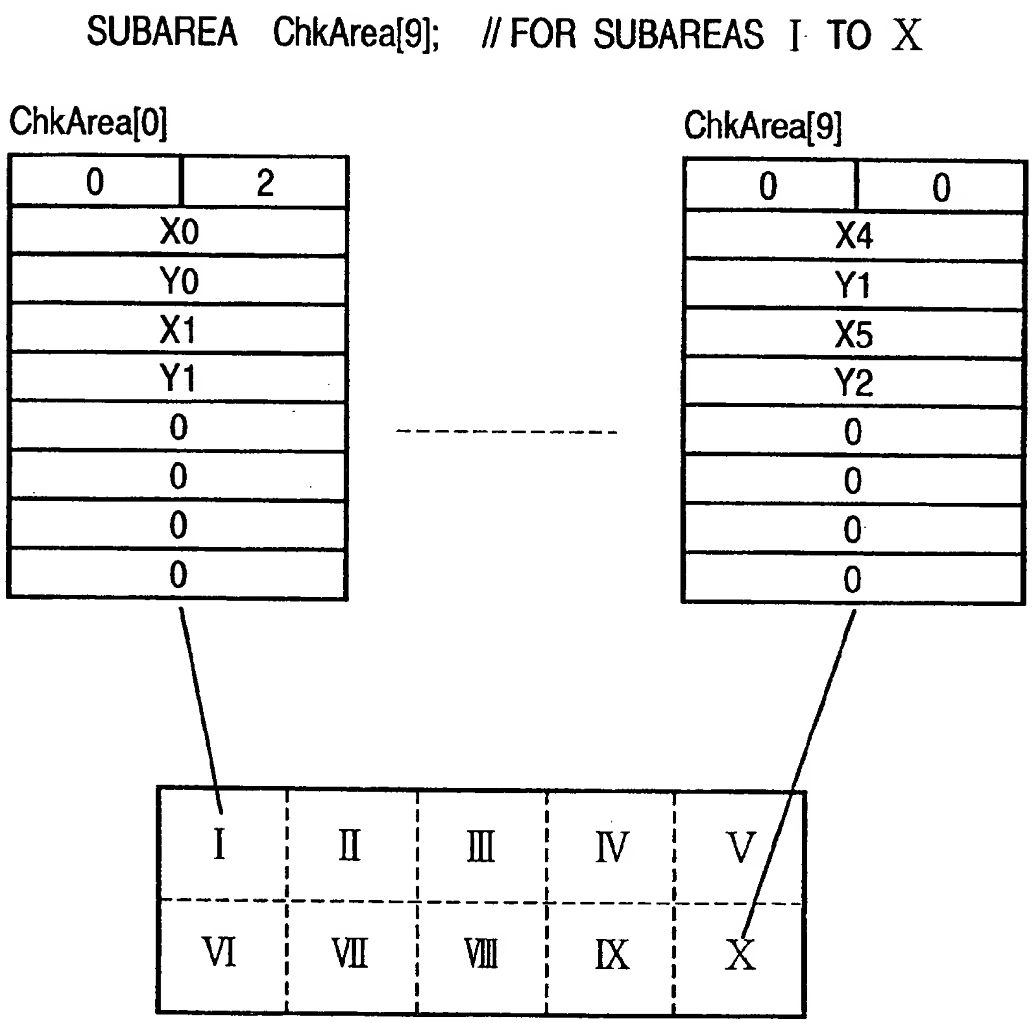

SUBAREA ChkArea[9]; // FOR SUBAREAS I TO X
ChkArea[0]
0
2
X0
Y0
X1
Y1
0
0
0
0
ChkArea[9]
0
0
X4
Y1
X5
Y2
0
0
0
0
I
II
III
IV
V
VI
VII
VIII
IX
X

FIG. 19

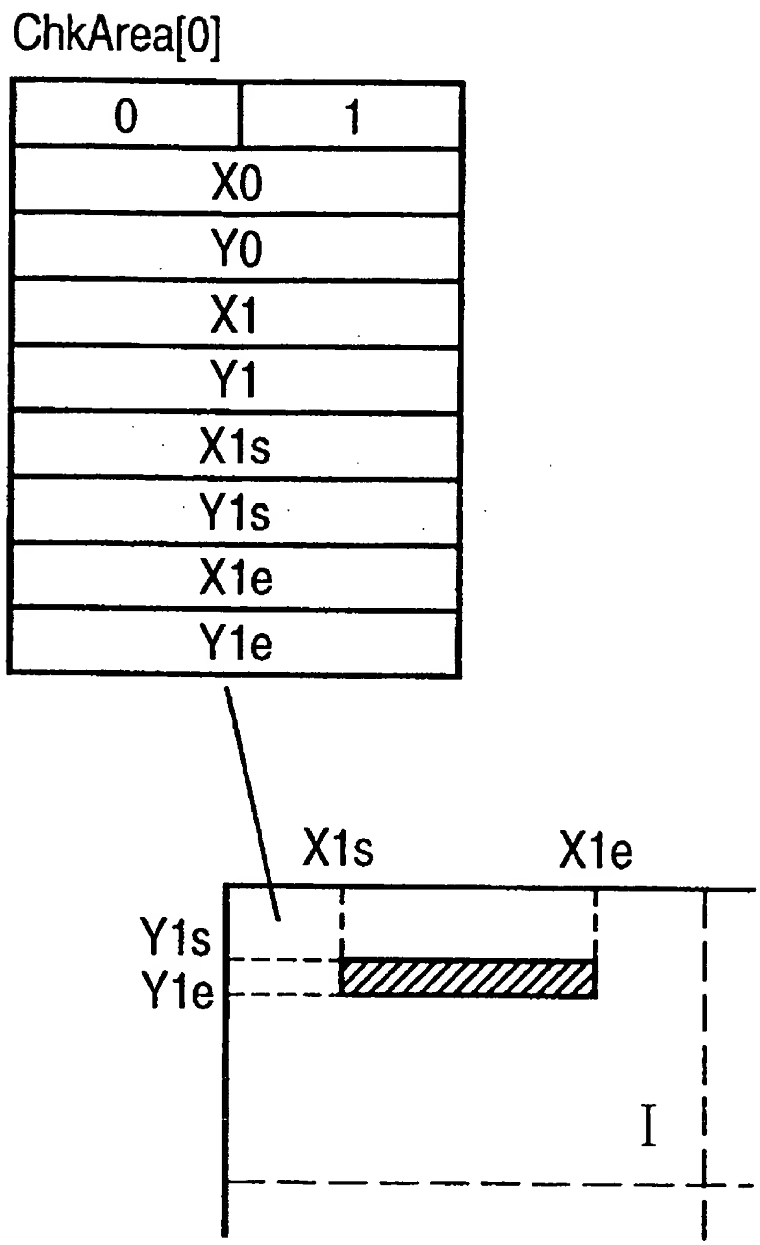


FIG. 20

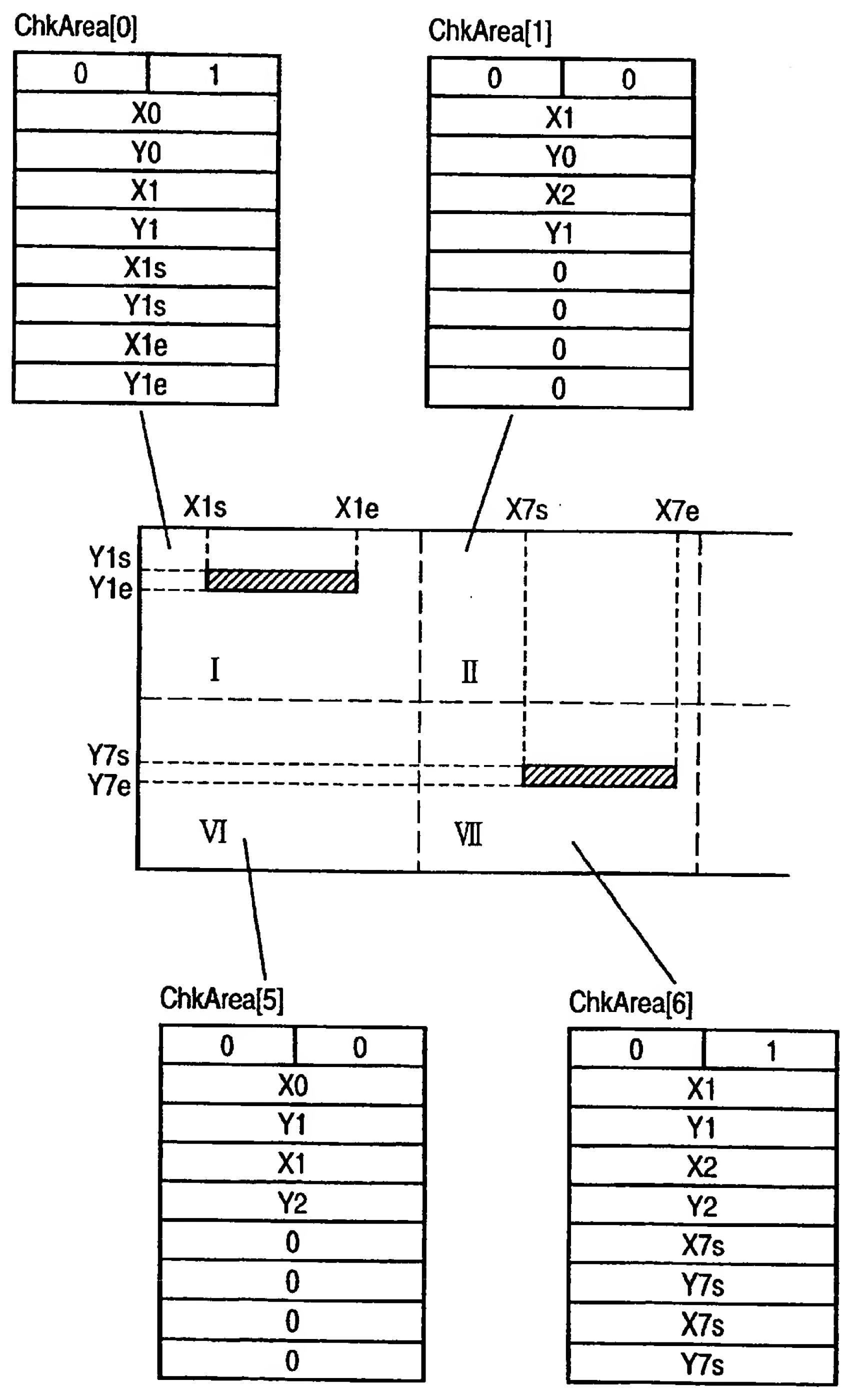

ChkArea[0]
0 1
X0
Y0
X1
Y1
X1s
Y1s
X1e
Y1e
ChkArea[1]
0 0
X1
Y0
X2
Y1
0
0
0
0
X1s
X1e
X7s
X7e
Y1s
Y1e
I
II
Y7s
Y7e
VI
VII
ChkArea[5]
0 0
X0
Y1
X1
Y2
0
0
0
0
ChkArea[6]
0 1
X1
Y1
X2
Y2
X7s
Y7s
X7s
Y7s

FIG. 21

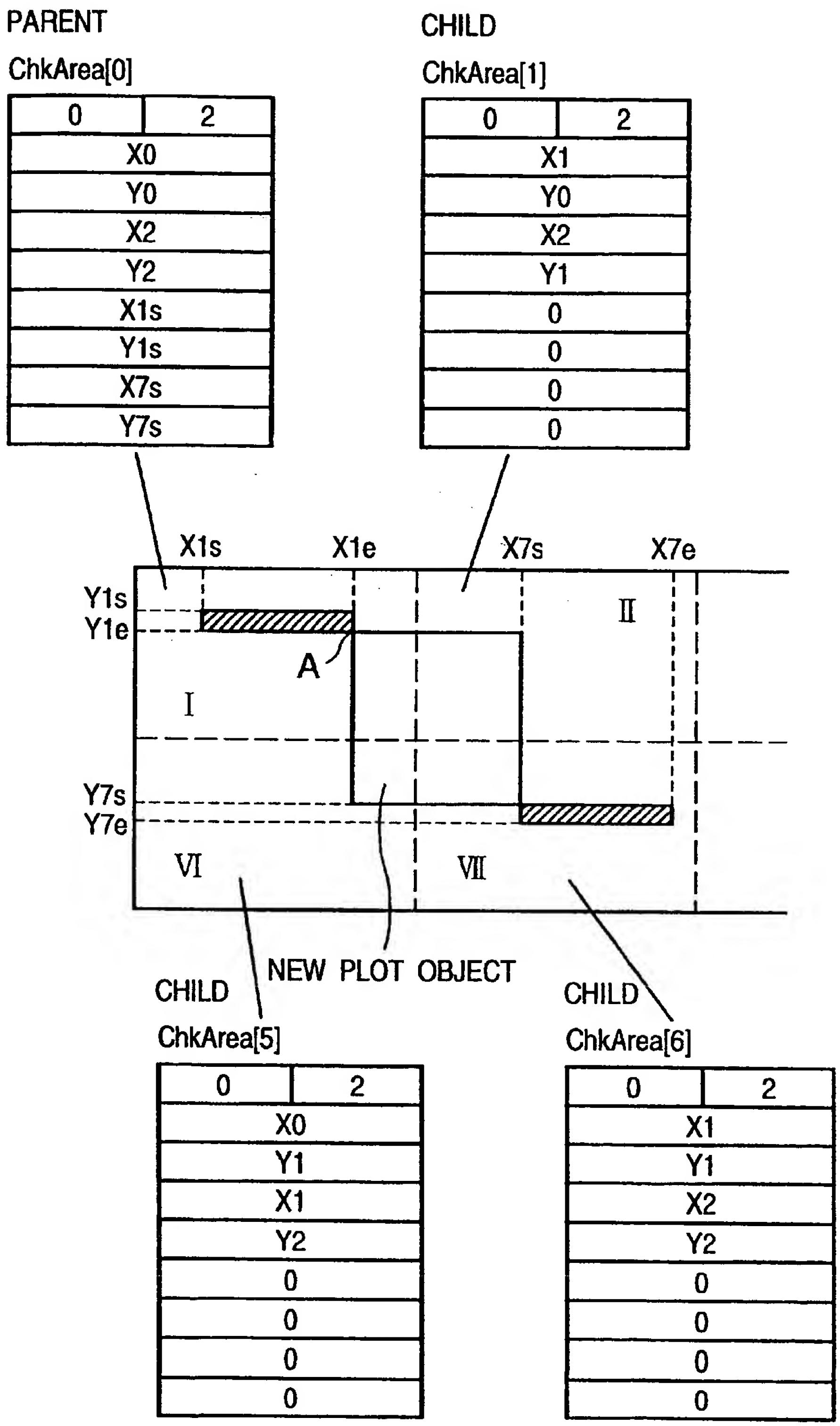

PARENT
ChkArea[0]
0
2
X0
Y0
X2
Y2
X1s
Y1s
X7s
Y7s
CHILD
ChkArea[1]
0
2
X1
Y0
X2
Y1
0
0
0
0
X1s
X1e
X7s
X7e
Y1s
Y1e
A
I
II
Y7s
Y7e
VI
VII
NEW PLOT OBJECT
CHILD
ChkArea[5]
0
2
X0
Y1
X1
Y2
0
0
0
0
CHILD
ChkArea[6]
0
2
X1
Y1
X2
Y2
0
0
0
0

FIG. 22

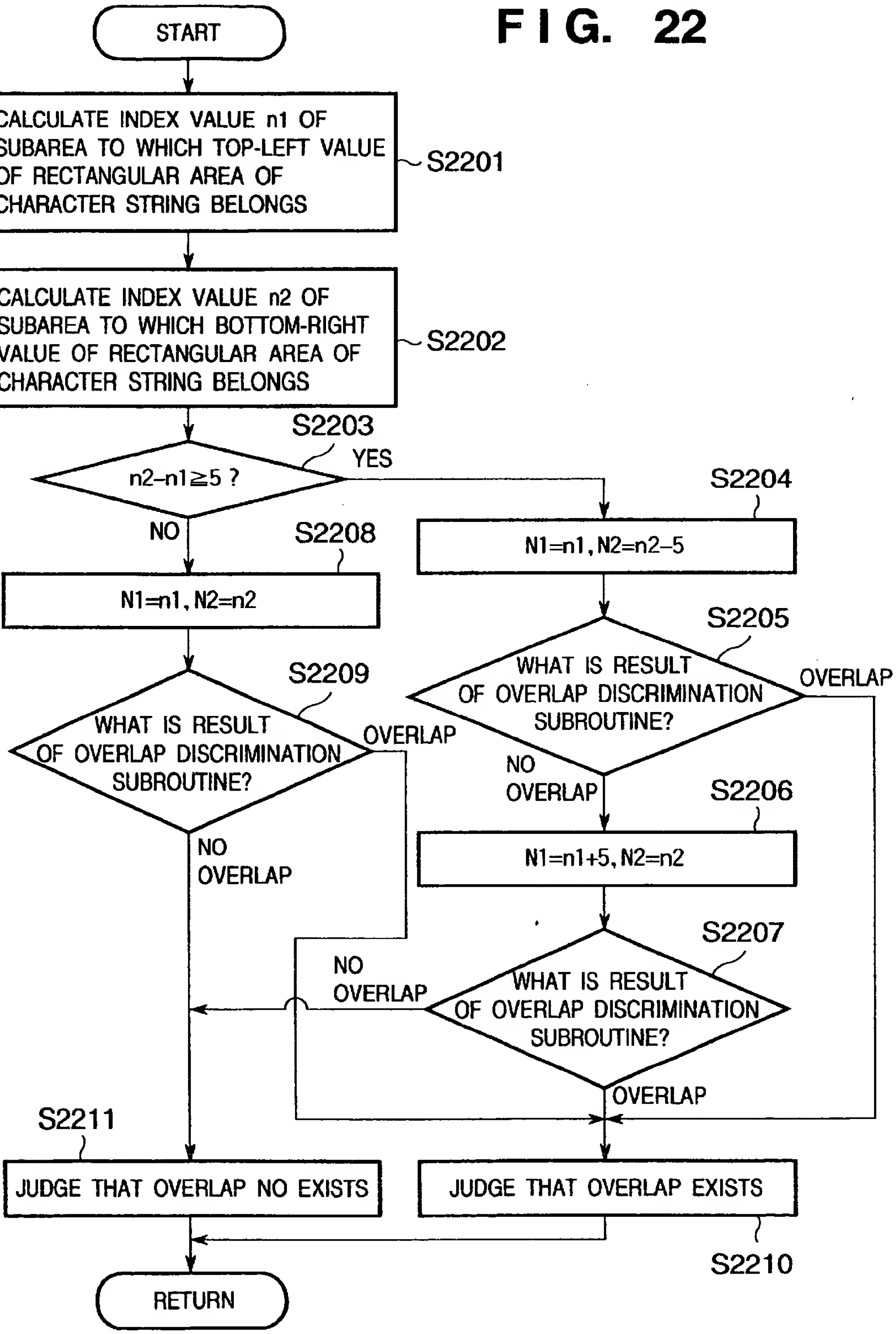

START
CALCULATE INDEX VALUE n1 OF SUBAREA TO WHICH TOP-LEFT VALUE OF RECTANGULAR AREA OF CHARACTER STRING BELONGS
S2201
CALCULATE INDEX VALUE n2 OF SUBAREA TO WHICH BOTTOM-RIGHT VALUE OF RECTANGULAR AREA OF CHARACTER STRING BELONGS
S2202
S2203
n2−n1≧5 ?
YES
NO
S2204
N1=n1, N2=n2−5
S2208
N1=n1, N2=n2
S2205
WHAT IS RESULT OF OVERLAP DISCRIMINATION SUBROUTINE?
OVERLAP
NO OVERLAP
S2209
WHAT IS RESULT OF OVERLAP DISCRIMINATION SUBROUTINE?
OVERLAP
NO OVERLAP
S2206
N1=n1+5, N2=n2
S2207
WHAT IS RESULT OF OVERLAP DISCRIMINATION SUBROUTINE?
NO OVERLAP
OVERLAP
S2211
JUDGE THAT OVERLAP NO EXISTS
JUDGE THAT OVERLAP EXISTS
S2210
RETURN

FIG. 23

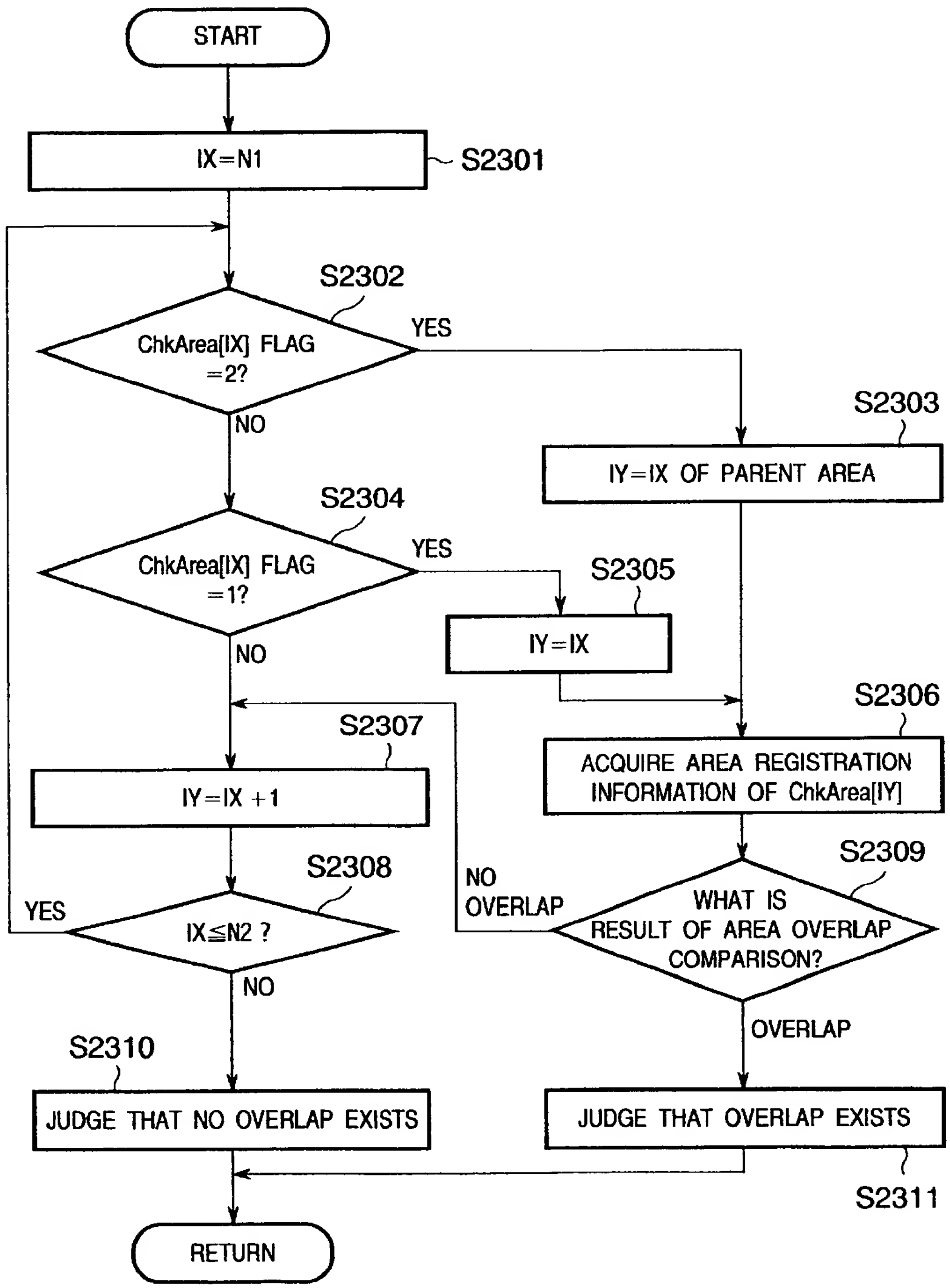

START
IX=N1
S2301
S2302
ChkArea[IX] FLAG =2?
YES
NO
S2303
IY=IX OF PARENT AREA
S2304
ChkArea[IX] FLAG =1?
YES
NO
S2305
IY=IX
S2306
ACQUIRE AREA REGISTRATION INFORMATION OF ChkArea[IY]
S2307
IY=IX +1
S2308
IX≦N2 ?
YES
NO
S2309
WHAT IS RESULT OF AREA OVERLAP COMPARISON?
NO OVERLAP
OVERLAP
S2310
JUDGE THAT NO OVERLAP EXISTS
JUDGE THAT OVERLAP EXISTS
S2311
RETURN

FIG. 24

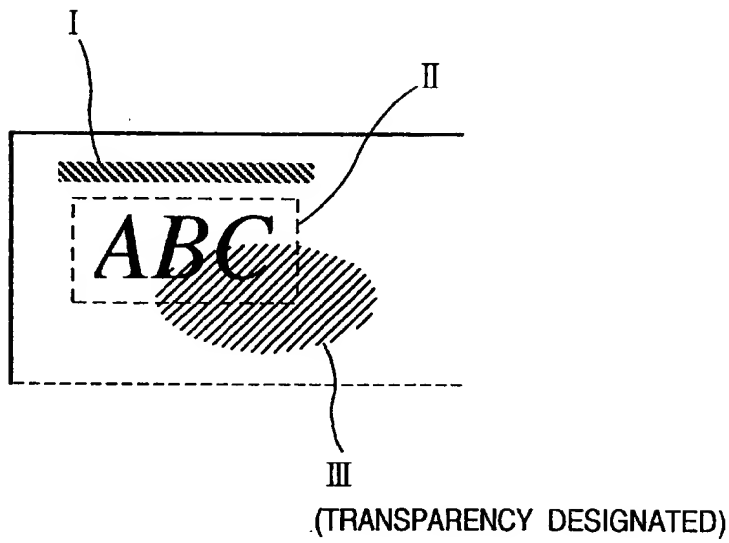
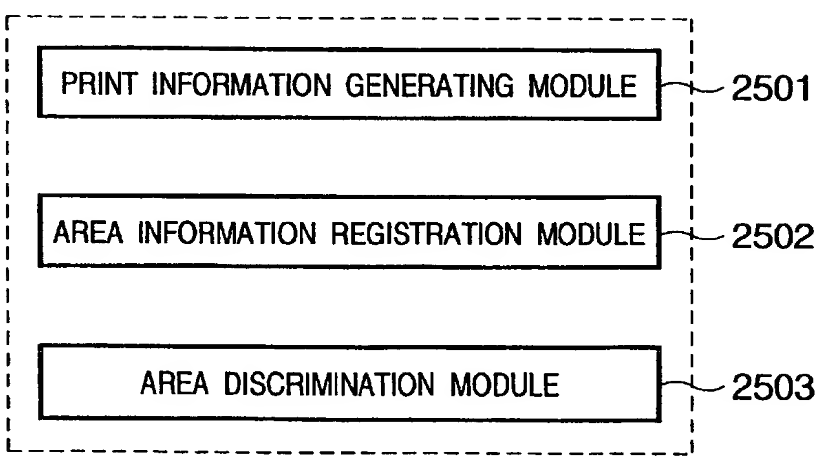

I
II
ABC
III
(TRANSPARENCY DESIGNATED)

FIG. 25


PRINT INFORMATION GENERATING MODULE
2501
AREA INFORMATION REGISTRATION MODULE
2502
AREA DISCRIMINATION MODULE
2503

PRINTING SYSTEM, PRINTING CONTROL METHOD, DATA PROCESSING APPARATUS AND METHOD, AND STORAGE MEDIUM THEREFOR

BACKGROUND OF THE INVENTION

This invention relates to a printing system constituting by a printing apparatus which operates upon receiving print information from a data processing apparatus (host computer), and a print data processing apparatus which is a combination of software modules referred to as printer drivers and device drivers that generate print information at the host computer side for the printing apparatus. The invention relates further to a printing control method, a data processing apparatus, a data processing method and a storage medium therefor.

A printing control method and the flow of processing in a conventional printing system will be described first.

In general, a printing system is constructed by connecting a host computer and a printing apparatus via parallel communication means, such as a Centronics interface, or via network communication means.

At the host computer, application software such as a word processor or spreadsheet runs on a so-called basic operating system such as Windows (the registered trademark of Microsoft Corporation). If printing is performed using the application software, the program implements printing using a graphic subsystem, which is one of several subsystems provided by the basic operating system.

The graphic subsystem, which is called GDI (Graphic Device Interface) in the Windows environment, supervises the processing of image information for a display or printer.

In order to compensate for dependency upon the particular device, such as a display or printer, the GDI dynamically links modules referred to as device drivers and executes output processing in regard to each device. The module for a printer is referred to as a printer driver. With a printer driver it is necessary to prepare a group of functions referred to as a DDI (Device Driver Interface) whose inclusion in the device driver is decided beforehand depending upon the capabilities and functions of the printer driver. In regard to the calling of an API (Application Programming Interface) of application software, the arrangement is such that the GDI performs a data conversion for the device driver, the group of DDI functions of this device driver are called from the GDI as appropriate and the prescribed print processing is executed. The GDI sequentially processes print requests from the application software via the printer driver. The processing of the printer driver can be classified into two types, namely a PDL type and an image type.

The PDL type is suitable for an arrangement in which the printing apparatus is equipped with a controller that is capable of processing a control command referred to as PDL (Printer Description Language). The processing involved is mainly processing for converting the DDI, which is delivered from the system, to a PDL command.

The image type, on the other hand, does not execute highly sophisticated plot processing on the side of the printing apparatus but rather expands print images on the side of the printer driver and sends the images to the printing apparatus so that they may be printed.

In processing for printing text, for example, the PDL-type processing mode performs printing by utilizing fonts incorporated in the printing apparatus or allocates IDs specific to character patterns expanded as necessary on the side of the printer driver in advance, first registers the character patterns on the side of the printing apparatus and then prints the characters based upon print position information and ID.

With the image-type processing mode, the printer driver possesses a plotter memory which stores data in band or full-page units, and characters are expanded in this memory. When one band or a full page of plot processing ends, the content of the plotter memory is transferred to the printing apparatus as image data and the prescribed image is printed out.

The prior art includes an arrangement in which the PDL and image types are utilized exclusively in one printer driver. In general, which should be utilized is decided by the user per se depending upon the content of the document to be printed, and the setting is made using the interface (referred to as a "user interface" below) of the printer driver.

The example of the prior art cited above has a number of problems.

(1) There are instances where it is difficult for the user to decide the optimum processing mode (PDL or image) from the content of a document.

Generally, the PDL processing mode is possible to process plain text data in high speed compared with the image processing mode.

However, the high speed performance of the PDL processing mode is not necessarily secured, because the processing performance depends on the contents of data.

For example, in case of a high resolution image such as a photograph taking up the entire side of a sheet of paper and having characters written thereon (see FIG. 3), it is highly likely that processing will be executed at higher speed by the image driver. That is, the processing time needed to obtain a printed result, which depends upon the size of the area plotted, whether there is a background beneath the characters and whether the document consists of a plurality of pages (i.e., whether or not there is a hit in the font cache), differs greatly depending upon the type of driver operation.

The image takes up the full side of a sheet of paper in the case of printing as shown in FIG. 3. Even if text separation processing is performed and the characters are cut from the document separately and processed as PDL in this case, there is an increase in the commands and textual data that are required for processing the characters as PDL. As a result, there is an increase in the overall print data and it is necessary to execute two kinds of processing, namely image plotting and text printing. The result is significant overhead from the standpoint of amount of processing.

In the case of such a full-page image, the superior choice is the image-type printer driver, in which characters also are pasted on the image expanded on the host side and the entirety is sent to the printer as an image.

(2) Allowing the user to select the optimum processing mode leads to ever more complicated user interfaces for the printer driver and is likely to lead to greater confusion for the user. Even in a case where it is attempted to lighten user load in regard to setting different conditions by allowing the setting of these conditions to be represented by icons, as shown in FIG. 4, there is still the danger that the user will be confused if a greater number of various printing modes is provided.

(3) A method that has been considered to solve the problems that arise when the selection is made by the user involves storing DDI information temporarily as a file and having the printer driver itself analyze this information to

thereby precisely determine the optimum processing mode. However, storing the DDI information temporarily as a file takes time, with the likelihood that performance will decline.

(4) In order to precisely determine the optimum processing mode, it is necessary to ascertain the correlation (extent of overlap) among plot objects. If there is a very large number of plot objects, the processing for detecting them will instead lead to greater overhead and may make the desired result unobtainable.

(5) When the degree of overlap between text and other plot objects is examined, ascertaining pattern overlap in the plotter memory is processing executed in units of pixels. Detection processing in pixel units leads to greater overhead and may make the desired result unobtainable.

For example, in a case where characters ABC, an ellipse having a hatched pattern and a single slanted line have been drawn closely together, as illustrated in FIG. 5, it is difficult to precisely ascertain the degree of overlap, if any. In such case, the conventional practice is to discriminate degree of overlap based upon information referred to as a "font boundary box", which encloses the character string in the manner indicated by the dashed-line box shown in FIG. 5. In such case, however, taking FIG. 5 as an example, despite the fact that there actually is no overlap between the rendered patterns of the respective objects, the result of area discrimination is that overlap exists (because the hatched portion and the dashed-line box are found to overlap).

In general, the prior art is such that the PDL- and image-type drivers are switched between on a print-job basis. However, a hybrid scheme in which these two types of drivers are used properly on a per-object basis in dependence upon the content of the print data also has been considered. However, the following problems arises when implementing a hybrid scheme of this kind:

(6) In a hybrid scheme, the components of both the PDL- and image-type drivers are combined. However, with the image-type implementation, for example, there are many cases where a banding approach is adopted from the viewpoint of using memory efficiently. In an instance where text is printed with such an arrangement, a DDI call for printing text takes place twice for characters that bridge bands even through characters are processed in PDL. More specifically, as illustrated in FIG. 6, a DDI call that clips the upper half of a character and expands it in an initial band is generated, then the lower half of the character also is clipped and this half is rendered in the next band. This form of processing is the same regardless of whether a driver is of the image type or PDL type because the processing step occurs at the processing stage of the DDI call. The processing of a character that spans bands in this manner invites a decline in processing speed because the printing of one character requires four steps ((1) the setting of a clipping area in band n, (2) the expansion of the character pattern, (3) the setting of a clipping area in band n−1 and (4) the expansion of the character pattern).

SUMMARY OF THE INVENTION

First, in regard to problem (1) cited above, whether a character to be printed has background is a key point when performing area discrimination.

In regard to problem (2), a preferred arrangement is one having an autonomous decision mechanism in which, in principle, the driver itself, rather than the user, makes decisions and printing processing is executed by the optimum processing method thus decided.

In regard to problem (3), it is desirable to adopt a method in which DDI information is judged sequentially (in real time) whenever it arrives, instead of an n-pass scheme in which DDI information is stored as a file in the first pass and the information in the file is examine to judge the information.

In regard to problem (4), it is preferred that processing speed be given priority consideration over strictness in terms of degree of overlap at the dot level in view of the fact that the gist of the present invention is an improvement in performance. Thus a scheme that makes judgments using information relating to a rectangle circumscribing a character string is desired.

In regard to problem (5), if a condition can be imposed to the effect that a character that has been cut from a document by text separation processing will not have any background, then, when printing is performed in PDL, there will no longer be the need for clipping and it will be possible to eliminate the second cycle of printing processing.

The present invention solves the above-mentioned problems mainly by the arrangements described below by taking into account the aforesaid methods of dealing with these problems.

Specifically, the present invention provides a printing system constituted by a printing apparatus and a data processing apparatus capable of communicating with the printing apparatus via a prescribed communications medium, the system comprising: print information generating means for generating print information, which is to be printed by the printing apparatus, in response to a print request command; area information registration means for registering, in a registration area, coordinate information of a plotting area of a print object generated as the print information; and area discrimination means for comparing the coordinate information registered by the area information registration means with character-string print position information when the character string is printed, and discriminating whether or not these two items of information overlap, wherein type of processing for printing the character string is switched based upon results of discrimination by the area discrimination means.

A print control method according to the present invention comprises: a print information generating step of generating print information regarding a printing apparatus in response to a print request command; an area information registration step of registering, in a registration area, coordinate information of a plotting area of a print object generated as the print information; and an area discrimination step of comparing the coordinate information registered at the area information registration step with character-string print position information when the character string is printed, and discriminating whether or not these two items of information overlap, wherein form of processing for printing the character string is switched based upon results of discrimination.

The present invention further provides a data processing apparatus for outputting print information to a printing apparatus via a prescribed communications medium, comprising: print information generating means for generating print information that is to be printed by the printing apparatus; area information registration means for registering, in a registration area, coordinate information of a plotting area of the print information that has been generated; area information updating means which, when the coordinate information is registered, is for updating the coordinate information as the maximum area that contains the plotting area; and area discrimination means for comparing the coordinate information registered by the area information registration means with character-string print

position information when the character string is printed, and discriminating whether or not these two items of information overlap.

The present invention further provides a data processing method for processing print information that is output to a printing apparatus, comprising: a print information generating step of generating print information that is to be printed by the printing apparatus; an area information registration step of registering, in a registration area, coordinate information of a plotting area of the print information that has been generated; an area information updating step which, when the coordinate information is registered, is a step of updating the coordinate information as the maximum area that contains the plotting area; and an area discrimination step of comparing the coordinate information registered at the area information registration step with character-string print position information when the character string is printed, and discriminating whether or not these two items of information overlap.

The present invention further provides a storage medium storing a data processing program for processing print information that is output to a printing apparatus, the data processing program comprising: code of a print information generating step of generating print information that is to be printed by the printing apparatus; code of an area information registration step of registering, in a registration area, coordinate information of a plotting area of the print information that has been generated; code of an area information updating step which, when the coordinate information is updated, is a step of updating the coordinate information as the maximum area that contains the plotting area; and code of an area discrimination step of comparing the coordinate information registered at the area information registration step with character-string print position information when the character string is printed, and discriminating whether or not these two items of information overlap.

The present invention further provides a storage medium storing a print control program, comprising: code of a print information generating step of generating print information, which is to be printed by a printing apparatus, in response to a print request command; code of an area information registration step of registering, in a registration area, coordinate information of a plotting area of a print object generated as the print information; and code of an area discrimination step of comparing the coordinate information registered at the area information registration step with character-string print position information when the character string is printed, and discriminating whether or not these two items of information overlap.

In accordance with a preferred embodiment of the present invention, the printing system described above further comprises first character printing means for printing a character pattern, which has been expanded on the side of the printing apparatus, if there is no overlap in the plotting area of the print object based upon results of discrimination performed by the area discrimination means; and second character printing means for printing a character pattern, which has been expanded by the data processing apparatus, as a bitmap image if there is overlap in the plotting area of the print object based upon results of discrimination performed by the area discrimination means.

In a preferred embodiment of the present invention, the area information registration means performs registration using area information relating to a rectangle circumscribing the plot object.

In a preferred embodiment of the present invention, the area information registration means registers, in the registration area, minimum values of top-left coordinates and maximum values of bottom-right coordinates of a rectangle circumscribing each plot object that is possibly background of text.

In a preferred embodiment of the present invention, the area discrimination means performs discrimination processing sequentially based upon print information generated sequentially in the print information generating means.

In a preferred embodiment of the present invention, the print information generating means generates print information that has been rasterized in units obtained by partitioning one page into a plurality of band areas.

In a preferred embodiment of the present invention, the print information generating means executes processing upon virtually connecting the plurality of band areas to expand them as one area in a case where a plotting area of a print object relating to a character bridges a plurality of the band areas according to the result of discrimination by the area discrimination means.

In a preferred embodiment of the present invention, the area information registration means and the area discrimination means perform registration and discrimination upon partitioning and managing a band area in the print information generating means as a plurality of sub-areas.

In a preferred embodiment of the present invention, the area information registration means saves, in the registration area, coordinate-value information which defines the maximum rectangular area that contains all print objects.

In a preferred embodiment of the present invention, the registration area has: a flag portion for identifying an attribute of the plotting area of the print object; a parent-area portion for identifying a parent area when the plotting areas are connected; a management area for saving coordinate information of the print object; and a registration area for saving area information of background of the print object.

In a preferred embodiment of the present invention, if the area discrimination means has discriminated overlap between an area of a character string processed as PDL and coordinate information of a subsequently entered print object which is background of the character string, the area discrimination means sets an image assurance flag for identifying the overlap and, after the image assurance flag has been set, subjects all print objects to print processing by the first character printing means, thereby eliminating inconsistency of printed results due to advance in the plotting order of the print objects.

In a preferred embodiment of the present invention, the printing system further comprises holding means for holding, on the side of the data processing apparatus, print information of a character string processed as PDL in the band area, wherein if the area discrimination means has discriminated that the area of the character string processed as PDL and coordinate information of a subsequently entered print object which is background of the character string overlap, the area discrimination means calls the print information of the character string being held by the holding means, performs expansion in a plotter memory by the data processing apparatus based upon the print information of the character string, and updates the coordinate information of the plotting area, which has been registered in the registration area, as well as the print information of the character string, thereby eliminating inconsistency of printed results due to advance in the plotting order of the print objects.

In accordance with a preferred embodiment of the present invention, the printing control system described above further comprises a first character printing step of printing a

character pattern, which has been expanded by the printing apparatus, if there is no overlap in the plotting area of the print object based upon results of discrimination performed at the area discrimination step; and a second character printing step of printing a character pattern, which has been expanded by the data processing apparatus, as a bitmap image if there is overlap in the plotting area of the print object based upon results of discrimination performed at the area discrimination step.

In a preferred embodiment of the present invention, the area information registration step performs registration using area information relating to a rectangle circumscribing the plot object.

In a preferred embodiment of the present invention, the area information registration step registers, in the registration area, minimum values of top-left coordinates and maximum values of bottom-right coordinates of a rectangle circumscribing each plot object that is possibly background of text.

In a preferred embodiment of the present invention, the area discrimination step performs discrimination processing sequentially based upon print information sequentially generated at the print information generating step.

In a preferred embodiment of the present invention, the print information generating step generates print information that has been rasterized in units obtained by partitioning one page into a plurality of band areas.

In a preferred embodiment of the present invention, the print information generating step executes processing upon virtually connecting the plurality of band areas to expand them as one area in a case where a plotting area of a print object relating to a character bridges a plurality of the band areas according to the result of discrimination at the area discrimination step.

In a preferred embodiment of the present invention, the area information registration step saves, in the registration area, coordinate-value information which defines the maximum rectangular area that contains all print objects.

In a preferred embodiment of the present invention, the registration area has: a flag portion for identifying an attribute of the plotting area of the print object; a parent-area portion for identifying a parent area when the plotting areas are connected; a management area for saving coordinate information of the print object; and a registration area for saving area information of background of the print object.

In a preferred embodiment of the present invention, if the area discrimination step has discriminated overlap between an area of a character string processed as PDL and coordinate information of a subsequently entered print object which is background of the character string, the area discrimination step sets an image assurance flag for identifying the overlap and, after the image assurance flag has been set, subjects all print objects to print processing by the first character printing step, thereby eliminating inconsistency of printed results due to advance in the plotting order of the print objects.

In a preferred embodiment of the present invention, the printing control system further comprises a holding step of holding, in a memory on the side of the data processing apparatus, print information of a character string processed as PDL in the band area, wherein if the area discrimination step has discriminated that the area of the character string processed as PDL and subsequently entered coordinate information of a print object which background of the character string overlap, the area discrimination step calls the print information of the character string being held in the memory, performs expansion in a plotter memory on the side of the data processing apparatus based upon the print information of the character string, and updates the coordinate information of the plotting area, which has been registered in the registration area, as well as the print information of the character string, thereby eliminating inconsistency of printed results due to advance in the plotting order of the print objects.

In a preferred embodiment of the present invention, the area discrimination means performs discrimination processing based upon print information without spooling.

In a preferred embodiment of the present invention, the area discrimination step performs discrimination processing based upon print information without spooling.

In a preferred embodiment of the present invention, the code of area discrimination step performs discrimination processing based upon print information without spooling.

It should be noted that, as a general rule, the present invention holds with the following assumption as a condition, and that a correctly printed result will be assured under this limited precondition (though this is a general rule at best; a way of coping with instances where the rule is violated will be described later in conjunction with a third embodiment): The precondition is that a plot object which is the background of a character contains the character, and that the DDI of a plot object constituting background is called before a text printing DDI at the time of print processing. Further, a plot object of the kind for which a logical operation is performed on a character is not drawn.

For example, in a case where printing of the kind shown in FIG. 7A is performed, the character string "File Name" has background. Characters in a case such as this are subjected to image-type processing without being cut out as characters to be processed in PDL. The discrimination method used at this time will be described in simple terms with reference to FIG. 7B. In an ordinary printed document, the background of a character string having such background surrounds the character string. In such case print commands which the system delivers to the printer driver also are processed in order starting from the information of the plotting area.

More specifically, in the case of FIG. 7B, first a ruled line (a straight line) of a table constituting background is delivered as a rectangular image to the printer driver by a DDI call DrvBitBlt ((1)). At this time the printer driver first registers, in prescribed area information storage means, two items of coordinate information, namely the point (point A) at the top left of this plot object (a rectangle in this case) and the point at the bottom right (point B, which, since this is a rectangular image of a straight line, is the point at the extreme right end of the straight line).

Next, a portion (rectangular) that is a hatched part of the table is delivered to the printer driver by a DDI call DrvBitBlt ((2)). Here also two items of coordinate information, namely the top-left point (point A) and bottom-right point (point C) of this rectangular area are registered in the prescribed area information storage means by area information registration means. However, this information is compared with the area information already registered, and a smaller value in the top-left direction and a larger value in the bottom-right direction are registered. In other words, the area information managed by the area information storage means is always taken as two points in this case.

The area information is referred to in this manner for each plot object so that the largest rectangular area that will contain these plot objects may always be ascertained. If the

next item arrived at under these conditions is a character string, it is determined whether there is overlap between information relating to a circumscribing rectangle that contains the character string and a rectangular area registered by the area information registration means thus far.

If there is even slight area overlap, it is judged that the character string includes background and, hence, the character string is subjected to processing of the image type. For example, in regard to "File Name" ((3)), a rectangular area defined by A' and C' and the hatched portion of (2) overlap.

On the other hand, if the result of area discrimination is that there is no overlap (e.g., the character-string portion "Tag.1" in FIG. 7B), this character string is subjected to processing of the PDL type. This makes it possible to instantly judge the optimum processing means at all times.

The foregoing is the principle of operation of the inventive means for solving the aforementioned problems. These means solve the problems of the prior art, make it possible to shorten the time needed for printing processing and provide a transition from operating mode decisions made by the user to autonomous operating mode decides made by the printer driver. As a result, it is no longer necessary to make settings through a complicated user interface, thereby improving operability for the user.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the description, serve to explain the principles of the invention.

FIG. 1 is a sectional view showing the structure of a laser printer to which the present invention is applicable;

FIG. 2 is a block diagram showing the basic overall configuration of a printing system according to an embodiment of the present invention;

FIG. 3 is a conceptual view showing an example of a print image and a difference in generated codes described in regard to the problems of the prior art;

FIG. 4 is a diagram showing an example of the user interface of a printer driver;

FIG. 5 is a diagram showing an example of a print image;

FIG. 6 is a conceptual view useful in describing processing when printing a character that bridges bands;

FIGS. 7A and 7B are schematic views of plot objects expanded in bands;

FIG. 8 is a conceptual view showing the flow of processing;

FIG. 9 is a diagram showing an example of a program in C language for area registration processing;

FIG. 10 is a diagram showing an example of a program in C language for area discrimination processing;

FIG. 11 is a diagram showing an example of a program in C language for text printing DDI processing;

FIG. 12 is a diagram showing an example of a print image in which desired effects cannot be expected in a first embodiment;

FIG. 13 is a diagram of band areas subjected to partitioning processing according to a second embodiment;

FIG. 14 is a flowchart showing the flow of processing executed by a printer driver;

FIG. 15 is a flowchart showing the flow of area registration processing according to the second embodiment;

FIG. 16 is a flowchart showing the flow of area connection processing according to the second embodiment;

FIG. 17 is a diagram showing a type declaration of a SUB-AREA structure used in the second embodiment;

FIG. 18 is a schematic view showing the initial state of an array for sub-area management according to the second embodiment;

FIG. 19 is a diagram showing the state of an array for management in a case where a rectangular area will fit in a sub-area;

FIG. 20 is a diagram showing the state of an array for management prior to sub-area connection processing according to the second embodiment;

FIG. 21 is a diagram showing the state of an array for management after sub-area connection processing according to the second embodiment;

FIG. 22 is a flowchart showing the flow of area discrimination processing according to the second embodiment;

FIG. 23 is a flowchart showing the flow of overlap discrimination processing according to the second embodiment;

FIG. 24 is a diagram for describing the elimination of inconsistency in the results of printing caused by advancing plotting order; and

FIG. 25 is a diagram for describing a memory map of a storage medium.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

<First Embodiment>

Before describing the construction of the present invention, we will discuss the structure of a laser printer, which performs the printing of a printing system to which the present embodiment is applied, with reference being had to FIG. 1.

FIG. 1 is a sectional view showing the structure of a laser printer. As shown in FIG. 1, the laser printer has a body **100**. Print information comprising print data (character codes, image data, etc.) and control codes supplied by an externally connected host computer are input to and stored in the laser printer, which proceeds to create the corresponding print image data and print images in accordance with this information and form an image on printing paper serving as a storage medium.

The laser printer has an operation panel **120** on which operation switches and LED indicators are arrayed, and a formatter controller **110** for controlling the laser printer and for executing printing processing upon analyzing textual information and the like supplied from the host computer. Print information that has been expanded in the formatter controller **110** is converted to a video signal of the corresponding pattern and the video signal is output to a laser driver **131**. The laser driver **131** is a circuit for driving a semiconductor laser **141**. A laser beam **142** emitted by the semiconductor laser **141** is switched on and off in dependence upon the entered video signal.

The laser beam **142** is swept back and forth by a rotating polygonal mirror **143** so as to scan and expose an electrostatic drum **144**. As a result, an electrostatic latent image of a character pattern is formed on the electrostatic drum **144**. The latent image is developed by a developing unit **145** surrounding the electrostatic drum **144**, after which the

developed image is transferred to printing paper. Cut sheets are used as the printing paper and are stored in a paper cassette 146 that has been loaded in the laser printer 100. The printing paper is fed into the apparatus by a feed roller 147 and transport rollers 148, 149 so as to be supplied to the electrostatic drum 144. Here transfer to the printing paper takes place so as to form the image.

The body 100 of the laser printer is equipped with one or more card slots (not shown) or memory slots (not shown) in which a memory such as a flash ROM is inserted. This makes it possible to connect an option font card, which provides fonts to supplement internal fonts, as well as a control card (emulation card) of a different language system (command scheme).

The printer to which the present invention can be applied is not limited to a laser printer, and it goes without saying that the printer may be a color laser printer or a printer that relies upon another printing technique, such as a ink-jet printer. FIG. 2 is a block diagram showing the basic overall configuration of a printing system embodying the present invention.

The formatter controller 110 of the printing apparatus 100 includes an interface (I/F) 111 serving as means for connecting the apparatus to a host computer 200, a receiving buffer 1121 for temporarily retaining and managing received data, a transmitting buffer 1122 for temporarily retaining and managing transmitted data, a PDL analyzer 113 for supervising the analysis of print data, a printing control processing execution unit 114, a plot processing execution unit 115 and a page memory 116, etc.

The interface 111, which serves as communications means for sending data to and receiving data from the host computer 200, is capable of communication in compliance with IEEE-1284 as the communications protocol. Print data received through the interface 111 is accumulated sequentially in the receiving buffer 1121, which serves as storage means for temporarily retaining this data, and the print data is read out and processed as necessary by the PDL analyzer 113 or plot processing execution unit 115. The PDL analyzer 113 is constituted by a control program that is in compliance with each PDL command scheme and print-job control language. A command that has been analyzed by the PDL analyzer 113 instructs the plot processing execution unit 115 to process the result of analyzing print data relating to the printing of characters and the plotting of graphics and images. Commands other than those for plotting, such as commands for paper-feed selection and reset, instruct the printing control processing execution unit 114 to execute processing.

The plot processing execution unit 115 sequentially expands text and image objects in the page memory 116. Further, when encoded image data is decoded and expanded in the page memory, the plot processing execution unit 115 executes data decoding processing. The page memory 116 may be managed based upon this expansion processing and stores print data which is sent as video signals to the printer engine. In other words, the page memory 116 may be managed by banding control. If there is enough memory, an area in which one page is capable of being expanded may be reserved. In general, the formatter controller 110 is constituted by a computer system composed of a central processing unit (CPU), a read-only memory (ROM) and a random-access memory (RAM), etc. The processing executed by the above-mentioned units may be time-share link processing executed under a multitask monitor (real-time operating system), or the processing may be executed independently by preparing special-purpose controller hardware for each function.

The operation panel 120 is for setting and displaying various states of the printing apparatus. An output controller 130 converts the content of the page memory 116 to a video signal and transfers images to a printer engine 140. The printer engine 140 is a printing mechanism for forming a received video signal into a permanent visible image on printing paper and is as described above in connection with FIG. 1. The paper cassette 146 is a removable device for storing paper.

The printing apparatus 100 is as described above. Described next will by the overall configuration of a printing system according to this embodiment, which includes the host computer 200.

If the functions of the present invention are executed, the present invention can be applied to a stand-alone device or to a system comprising a plurality of devices which execute processing via a network such as a LAN.

In FIG. 2, the host computer 200 serving as a data processing apparatus in the printing system outputs print information comprising print data and control codes to the printing apparatus 100. The host computer 200 is constructed as a computer system having a keyboard 210 serving as an input device, a mouse 211 serving as a pointing device, and a display monitor 220 serving as a display device. It is assumed that the host computer 200 is operated by a basic operating system such as Unix or Windows. If attention is directed solely to the inventive functions provided at the host computer, the functions on the basic operating system can be classified broadly into the functions of application software 201, a graphic subsystem 202, which serves an image information processing means, and a spool subsystem 203, which includes data storage means, print-data storage control means and communication means for communication with the printing apparatus.

The application software 201 refers to applications software, such as a word processor or spreadsheet, that is run on the basic operating system. The graphic subsystem 202 is constituted by a Graphic Device Interface (referred to as a "GDI" below) 2021, which is one of the functions of the basic operating system, and a printer driver 2022 serving as a device driver linked dynamically from the GDI.

The component referred to as the printer driver is print information generating means according to the present invention. The spool subsystem 203, which is a subsystem specific to a printer device and is situated downstream of the graphic subsystem 202, includes devices such as a spool file (a hard disk in actuality) 2031 serving as data storage means. Depending upon the type of basic operating system, the device names and functional framework mentioned above may differ. However, if the devices are modules in which the various technical means of the present invention can be implemented, the names and functional framework thereof do not have that much significance as far as the present invention is concerned. For example, what is referred to as a spooler or spool file can be implemented by incorporating the processing in a module called a print queue in a different operating system.

In general, the host computer 200 that includes these functional modules consists of such hardware as a CPU, a ROM, a RAM, a hard-disk drive (HDD) and various input/output (I/O) units. Software referred to as basic software supervises control of this hardware, and respective application software subsystem processes operate as functional modules under this basic software.

The components that construct the present invention have been described on the basis of FIGS. 1 and 2. The operation

of the present invention will now be described with reference to the flow of processing in conjunction with FIG. 8.

FIG. 8 is a conceptual view showing the flow of processing according to the present invention. The flow of processing will be described taking as an example a case in which printing of the kind shown in FIG. 7A is performed. FIG. 7B shows the print image of an initial band area of data composed of a table of the kind often used in spreadsheet software and a character string indicating numbers in the table.

First a ruled line (a straight line) of the table constituting background is delivered as a rectangular image to the printer driver by a DDI call indicated by DrvBitBlt (D1). At this time the printer driver first delivers two items of coordinate information, namely the point (point A) at the top left and the point (point B) at the bottom right of this plot object (a rectangle in this case because despite the fact that the object appears to be a straight line, it has thickness and therefore is rectangular in shape) to an area-information registration processor, which then processes the coordinate information. The area-information registration processor, which is area information registration means according to the present invention, exists as software within the printer driver and registers the delivered rectangle information (top left and bottom right) to a prescribed area information storage area.

This area information storage area exists as a global variable within the printer driver and is also initialized whenever a band is updated. Since the plot object of D1 is the first plot object in the band, the area information of D1 is registered as is. For area registration from this point onward, registration is managed on each occasion based upon a comparison with information that has been registered thus far. Area information registration processing is executed by referring to and updating ChkRECT, which is a global variable area for area management.

Specifically, as shown in FIG. 9, area TrgRECT of the plot object of interest and ChkRCT are compared, values smaller than the top-left coordinate values and values larger than the bottom-right coordinate values are sought, and the ChkRECT variable is updated by these values. In other words, the largest rectangular area in which several print objects of interest are contained is calculated. While the above-described area registration processing is being executed, the area information of the text printing DDI up to just before the arrival of the DDI is examined.

For example, a portion (rectangular) that is a hatched part of the table is delivered as the print object that follows D1 to the printer driver by a DDI call indicated by DrvBitBlt (②). Here also two items of coordinate information, namely the top-left point (point A) and bottom-right point (point C) of this rectangular area are delivered to the area information processor by the area information registration means. This information is then processed. If in this flow of processing a character string arrives next in a state in which several plot objects that might possibly constitute background of characters have been processed, area discrimination processing is executed to determine whether there is overlap between information relating to a circumscribing rectangle that contains the character string and a rectangular area registered by the area information registration means thus far.

In other words, area discrimination processing for determining whether there is even slight overlap of an area that has been stored in the previously registered and updated ChkRECT variable is executed. Specifically, this area discrimination processing is implemented by a program of the kind shown in FIG. 10.

If the processor of the DDI for text printing is expressed by more concrete program code, the result is as shown in FIG. 11. If the result of the above-described area discrimination processing is that a print object to be processed overlaps ChkRECT even slightly, then this text printing processing is executed by the plot processing execution unit on the side of the host computer. (This is second text printing processing.) On the other hand, if there is no overlap with ChkRECT, then the text printing processing performs a conversion to PDL code within the printer driver and the code is allocated in such a manner that actual printing processing is carried out by the plot processing execution unit on the printer side. (This is first text printing processing.)

The band of image data for which plot processing has been executed on the host side is expanded in the plotter memory on the printer side, and textual data that has been sent to the plotter memory as PDL code is subjected to printing processing. However, since the character pattern processed as PDL code and the area for which plot processing has been executed on the host side do not overlap, there will be no change in the result of the final printed image output even if the processing sequence is reversed. Thus, reversing the processing sequence does not lead to any problems.

In accordance with the present embodiment, it becomes possible for a printer driver to decide optimum processing means autonomously and instantly at all times.

<Second Embodiment>

In the first embodiment set forth above, the focus of the description is the basic mechanism of processing according to the present invention. In order to utilize the present invention in more practical areas, it is preferred that the processing described next be adopted. The reason for this is that it is surmised that the desired effects will not be obtained when printing of the kind shown in FIG. 12 is processed according to the first embodiment. Specifically, in a case where a document is mainly text and there is no text background such as patterns or images, higher speed usually is obtained with PDL-type processing.

However, if the area discrimination method of the first embodiment is applied to a situation where two vertical lines have been provided on a document, one on the right side and one on the left side, for reasons of design, the entire textual data portion between the two vertical lines also undergoes image-type processing. Since the area that will be registered by area registration processing in such case is the coordinates of the left and right ends of the lines A and B, area discrimination at the time of text printing always decides that there is overlap despite the fact that there is no pattern overlap in actuality. The result is that the entire document is treated as image data, a large quantity of data is sent to the printer and, if the document consists of a plurality of pages, the reutilization of character patterns (whether or not there is font cache hit) is not effective. As a consequence, there is no increase in printing throughput. The second embodiment is intended to deal with the foregoing problem and represents a more practical embodiment.

A characterizing feature of the second embodiment is that area management is performed by dividing the area in a band into ten areas of the kind shown in FIG. 13. Adopting this expedient makes it possible to apply text separation processing suitably to a printing scenario of the kind shown in FIG. 12. The flow of processing of this embodiment will be described with reference to the flowchart of FIG. 14.

FIG. 14 is a flowchart showing the flow of processing executed by a printer driver, namely processing executed on

the host side of the printing system of the present invention. This processing is composed of steps S1401 to S1410. The printer driver implements a banding scheme with regard to image expansion.

Banding refers to a method of partitioning a page into several portions and generating print information rasterized in the units obtained by partitioning.

First, at step S1401, the printer driver checks to determine whether this is the initial DDI processing in each band. If this is initial processing, initialization processing of the array ChkArea[ ] for sub-area management is executed, this array being a variable that is effective in the processing of this band. The array for sub-area management takes on the values shown in FIG. 18 in the initialized state. The ChkArea[ ] variable is a SUB-AREA-type variable. The SUB-AREA type is defined in the manner shown in FIG. 17.

More specifically, the variable is composed of a flag portion 1702 for identifying whether a plotting area of a partitioned print object is connected, independent or unregistered, a parentArea portion 1701 for identifying an area that becomes a parent when plotting areas are connected, management areas for retaining coordinate information of a print object and registration areas for retaining area information relating to background. The management and registration areas are designated by numerals 1703 to 1710.

Next, it is determined at step S1403 whether the DDI is a text printing DDI. If the decision is "NO", control proceeds to step S1404, where the area information of a rectangle circumscribing this plot object is extracted from each parameter of the DDI. This is followed by step S1405, at which area registration processing is executed using this rectangular area information. Though not illustrated, this area is registered unconditionally in relation to the first print object in the band. The details of area registration processing will be described later. After the area has been registered, plot processing suited to each plot object is executed. The plot processing at step S1406 is the same as that of already existing printer drivers. The flow of processing for plot objects other than text has been described above. Processing in a case where a text printing DDI is discriminated at step S1403 will now be described.

In case of a text printing DDI, control first proceeds to step S1407, at which information relating to a rectangle circumscribing a character string is extracted from each parameter of the DDI. As for the text circumscribing rectangle, which is referred to as a "font boundary box", the graphic subsystem calculates the values thereof in advance and delivers them to the printer driver as DDI parameters. Next, the information relating to the rectangular area circumscribing the character string is compared with the area information relating to plot objects other than text registered thus far. In other words, area discrimination processing is executed at step S1408. The details of area discrimination processing will be described later.

If the result of discrimination processing executed at step S1408 is overlap, then image-type print processing is executed at step S1409. That is, processing for expanding a character pattern in the plotter memory on the host side is executed.

If it is judged that there is no overlap, PDL-type print processing is executed. That is, a font selection instruction and a text printing instruction in which character codes are the parameters are generated on the host side, and processing for expanding character patterns in the plotter memory on the printer side is executed in accordance with these PDL instructions. The general flow of processing executed by the printer driver in the present invention has been described above. The details of area registration processing and area discrimination processing, which are characterizing features of the present invention, will now be described in detail.

FIG. 15 is a flowchart showing the flow of area registration processing, which is composed of steps S1501 to S1506. It is determined at step S1501 whether a rectangular area given as an argument in this area registration processing will fit inside one area of the ten sub-areas (see FIG. 13) obtained by partitioning.

For example, in a case where a straight line of the kind shown in FIG. 19 is drawn, the straight line will fit into sub-area ①. In this case, therefore, control proceeds to step S1504. Here processing is switched upon observing whether the sub-area of interest is an area for which a connection flag (described later) has been set.

If this is a connected area ("YES" at step S1504), control proceeds to step S1505. If the area is an independent sub-area, on the other hand ("NO" at step S1504), then control proceeds to step S1506.

If it is found at step S1501 that the rectangular area will not fit into one sub-area but extends across a plurality of sub-areas, control proceeds to step S1502, where the sub-areas that correspond to these sub-areas numbers are obtained. Next, at step S1503, the relevant sub-areas are connected to construct a new sub-area of larger size.

This enlarged sub-area also is managed by the area ChkArea[ ] variable for sub-area management. The information on the composition of this area is subjected to area connection processing. This processing will be described later.

A sub-area of enlarged size can be produced by gathering several sub-areas together. Area information regarding a new sub-area in which the top-left-most sub-area is the parent sub-area is managed at step S1505. Sub-areas other than the parent sub-area are child sub-areas. In an array for managing the child sub-areas, a flag indicating that sub-areas have been connected is set and an index area of the parent sub-area is stored. In the case of a child sub-area, area information concerning an enlarged new area is not managed and indicates in its entirety a parent sub-area.

The values of the rectangular area delivered to area registration processing is registered in the area information storage area within a sub-area of interest. At the time of registration, smaller coordinate values at the top left and larger coordinate values at the bottom right are obtained by processing for making a comparison with already stored area information, and variables are updated by these values, as described in the first embodiment, at step S1506.

Described next will be the details of area connection processing used in the area registration processing of this invention. FIG. 16 is a flowchart showing the flow of area discrimination processing, which consists of steps S1601 to S1608. Area connection processing involves connecting a plurality of sub-areas, enlarging the management area on one side, stipulating a parent-child dependency relationship as a variable for sub-area management and reducing the number of variables managed.

From the coordinate values of the top-left point of a new rectangular area delivered as an argument, an index number n1 of the sub-area to which this point belongs is obtained. FIGS. 20 and 21 will be referred to in order to describe this in greater detail.

FIGS. 20 and 21 illustrate plot images of sub-areas ①, ②, ⑥, ⑦ within a band area as well as the states of

sub-area-management array variables for managing these images. FIG. 20 shows the state prior to sub-area connection processing, and FIG. 21 shows the state after sub-area connection processing, which will now be described. A description will be rendered taking as an example a case where a rectangular region not having a filling pattern is drawn in FIG. 20 as a new plot object of the kind shown in FIG. 21. If the step S1601 in the flowchart of FIG. 16 is applied to FIG. 21, the value of n1 obtained here specifically indicates the sub-area (1), and n1=1 holds.

Control then proceeds to step S1602, at which a comparison involving the area in sub-area n1 is performed. In the case of FIG. 21, a straight line has already been drawn in sub-area 1, and this information has been registered as X1*s*, Y1*s*, X1*e*, Y1*e* in the area information registration area of ChkArea[0]. If this area information is compared with area information X1*e*, Y1*e* of point A at the top left of the new plot object, it is found that the already registered area information is indicative of smaller coordinate values of the top-left point. In this case, therefore, no updating is performed. Thus, at step S1602, a comparison of the areas in the sub-area is performed and updating is carried out using the smaller top-left coordinate values.

This is followed by step S1603, at which this sub-area is defined as being the parent. In FIG. 21, the flag of ChkArea [0] becomes 2 (1702 in FIG. 17), meaning that sub-areas have been connected, and the number of parentArea (1701 in FIG. 17) becomes 0 (the index number of the array of sub-area (1)), indicating that this sub-area itself is the parent. Next, at step S1604, the bottom-right coordinates of the rectangular area information of the new plot object are checked, the sub-area to which this point belongs is specified and this index number is made n2. At the moment n2 is obtained, the structure refRect.right (1705 in FIG. 17) and refRect.bottom (1706) of the management variable ChkRect [n1] of the parent area is updated.

In the case of FIG. 21, sub-area (7) applies to n2. Accordingly, n2=7 holds and refRect.right (1705 in FIG. 17) and refRect.bottom (1706 in FIG. 17) of ChkRect[0] become X2 and Y2, respectively. Next, an area comparison regarding the bottom-right coordinates is performed at step S1605. The area information is updated by a larger bottom-right value. In this case the information in the variable area of the parent sub-area n1 is updated.

More specifically, in FIG. 21, the values of "right" and "bottom" of the information regRect of ChkArea[0] managing sub-area (1) are updated. In other words, X7*s* is stored in regRect.right (1709 in FIG. 17) of ChkArea[0] and Y7*s* is stored in regRect.bottom (1710 in FIG. 17).

The value of the management variable Chkarea[n1] of the sub-area that is the parent thus far is updated. From this point onward, updating of the management variables of the dependent child areas is performed.

First, in order to obtain the dependency range, n2−n1 is calculated at step S1606 and processing splits depending upon whether the difference is equal to or greater than 5. If the difference is equal to or greater than 5 ("YES" at step S1606), this indicates that the sub-area in the band spans two levels in the Y direction.

In such case, at step S1607, the flag of ChkRect[ ] from sub-area (n1+1) to (n2−5) and from sub-area (n1+5) to n2 is made 2 (indicating "connection"), and the number of parentArea is updated to 0, which is the index value of the array of management variables of the parent area. As a result, the parent-child dependence relationship is constructed in the sub-area, and a sub-area having this relationship is recognized as being a new sub-area.

Next, the details of area discrimination processing according to the second embodiment of the invention will be described.

FIG. 22 is a flowchart showing the flow of area discrimination processing, which consists of steps S2201 to S2211. First, it is determined to which sub-area a rectangle circumscribing a character string of interest is related. This entails finding the index value n1 of the sub-area to which the top-left value of the rectangle circumscribing the character string belongs (step S2201) and finding the index value n2 of the sub-area to which the bottom-right value of the rectangle circumscribing the character string belongs (step S2202).

Next, at step S2203, n2−n1 is calculated and processing splits depending upon whether the difference is equal to or greater than 5. If the difference is equal to or greater than 5, this indicates that the sub-area in the band spans two levels in the Y direction. In such case, area information that has been registered in the respective management areas is compared for the first level of X-direction sub-areas n1 to (n2−5) at steps S2204, S2205, and area information that has been registered in the respective management areas is compared for the second level of X-direction sub-areas (n1+5) to n2 (steps S2206, S2207). An overlap discrimination routine used at steps S2205, S2207, S2209 will be described later.

If it is found at step S2203 that the investigated area does not span two levels ("NO" at step S2203), control proceeds to step S2208 and overlap discrimination is performed in regard to sub-areas n1 to n2 (step S2209). The result of overlap discrimination at steps S2205, S2207, S2209, namely a decision that overlap does or does not exist, is adopted as a return value of area discrimination processing, after which processing returns.

Finally, overlap discrimination processing used in the area discrimination processing according to the second embodiment of the invention will now be described in detail.

FIG. 23 is a flowchart showing the flow of processing of the overlap discrimination subroutine, which consists of steps S2301 to S2311. In FIG. 23, IX, IY represent variables used in the overlap discrimination routine, and N1, N2 indicate arguments set by the side that calls the overlap discrimination routine. First, at step S2301, N1 is substituted into IX. Next, at step S2302, the value of the flag of ChkArea[IX], which is the sub-area management array, is examined. If the value is 2, i.e., if the sub-area is a connected sub-area, control proceeds to step S2303. If the value is not 2, control proceeds to step S2304. The value of the flag is examined in similar fashion. If the value is 1, i.e., if the sub-area is an independent sub-area, control proceeds to step S2305. If the value is not 1, i.e., in a case where drawing has not taken place even once in regard to this sub-area, the value if IX is incremented at step S2307 and the next sub-area is retrieved.

Next, at step S2308, it is determined whether all sub-areas from the sub-area N1 of interest to the sub-area N2 have been examined. If the entire examination has been completed at step S2308, it is judged that there is no overlap with any area (step S2310).

The index number of the parent area is substituted into the variable IY at step S2303, and IX is substituted into the variable IY at step S2305.

Next, step S2306 calls for the acquisition of the value of regRect, which is the area information of ChkArea[IY] that is the management array of the sub-area undergoing investigation, and for comparison with the information of the rectangular area circumscribing the character string. The

overlap comparison at step S2309 is the same as the method illustrated as a program in FIG. 10 described earlier. If the result of the comparison is that there is no overlap, control returns to step 2307 and the next sub-area is examined. If the result of the comparison is that there is overlap, this result is returned as a return value.

By virtue of the method described above, a character string that does not have background can be cut from a document in highly precise fashion.

<Third Embodiment>

In the first and second embodiments described above, a hatched pattern or the ruled lines of a spreadsheet that constitute background of text ordinarily surround the text. Therefore, the embodiments hold on the precondition that the text comes later also in a case where information is delivered as the DDI, and an effect obtained is higher print processing speed. In the third embodiment, however, the present invention is shown to be applicable even in a case where this precondition is not satisfied.

By way of example, assume, as shown in FIG. 24, that plot information of a rectangle (the bold straight line) was input first as ①, that the character string "ABC" was input next as ②, and that an oval plot with a transparency designation constituting background was input last as ③. Since the area ① and the character string ② do not overlap in terms of their areas, the character string ② is processed as PDL in accordance with the present invention. That is, the plot of the rectangle ① is expanded in the plotter memory on the host side by the plot processing execution unit on the host side. However, the character string ② is subjected to print processing in the plotter memory on the printer side by the plot processing execution unit on the printer side. Accordingly, in a case where the plot object ③ was entered next, the first and second embodiments are such that if the plot object ③ is expanded in the plotter memory on the host side and, at the stage where the plotting of ③ ends, there is no other plot object in this band, the content of the plotter memory in which ① and ③ have been rendered is sent to the printer side as an image and the character string ② is printed by being overwritten on this image. As a result, the transparency designation of the plot object ③ loses its meaning and a correct printed result is not obtained.

In other words, if a plot instruction that makes reference to the plotting area of character string (2) arrives after this area, there is the possibility that the correctness of the printed result will be lost. According to this embodiment, there are two solutions to this problem.

The first solution involves separately managing also the area information of text that has been processed as PDL and judging whether a plot object that is rendered after the text overlaps this area. At the moment overlap with a character string processed as PDL is revealed, the correctness of the image is assured by either of the methods set forth below.

<Method 1>

At the moment overlap with the area of a character string processed as PDL is found, a flag referred to as an "image assurance flag" is set, and the content of the plotter memory processed by the plot processing execution unit on the host side thus far is sent as an image to the printer side using a PDL command. Following the setting of the image assurance flag, the discrimination processing of the present invention is skipped and all subsequent processing is executed in PDL. Though it is possible that this method will not provide optimum performance, the correctness of the image (no inconsistency of printed results due to advance in the plotting order) is assured.

If this method is applied to the printing of FIG. 24, overlap with the area of character string ② that was processed as PDL is revealed at the moment the plot object ③ is processed. First it is construed that expansion has taken place thus far in the plotter memory on the host side, the content of the plotter memory in which the rectangle ① has been rendered is sent as an image to the printer using a PDL image plot command and all processing that follows the processing of ③ is performed as PDL.

<Method 2>

Within the band, print information (typeface, character code, printing position) of a character string processed as PDL is temporarily retained in the memory on the host side. At the moment overlap with the area of a character string processed as PDL is revealed, the print information of the character string being temporarily retained is called from memory and rendering in the plotter memory on the host side in accordance with this information using the plot processing execution unit on the host side.

At this stage the information for area management is updated and so is the character printing area per se. As a result, a correct print image that is in accordance with the order of plotting thus far is formed in the plotter image on the host side. The temporarily retained character-string print information is discharged as this stage and it is possible to continue with ordinary processing of the printer driver. In a case where the print image processed on the host side is sent to the printer side, any rendering or printing that will become background is erased. In order to accomplish this, overwrite plotting is designated and then the image is sent.

If this method is applied to the printing of FIG. 24, overlap with the area of character string ② that was processed as PDL is revealed at the moment the plot object ③ is processed. First the print information of the character string ② temporarily stored thus far in the memory on the host side is called and character print processing is applied to the content of the plotter memory on the host side. Next, area information being managed by the area information of the character string is updated by the area registration means. The plot object ③ is then expanded in the plotter memory on the host side and all plot processing ends. The content of the plotter memory on the host side, therefore, is sent to the printer as image data and the data is printed.

At this time drawing of the image data by overwriting is designated. On the printer side the information of character string ② has already been input as PDL data. After this processing is executed, the text is overwritten by the image expanded on the host side, thereby forming the print image.

By virtue of Methods 1 and 2 described above, the correctness of images can be maintained in the present invention as well.

<Fourth Embodiment>

This embodiment aims to make character print processing more efficient by distinguishing between text and plot objects other than text. It is also desirable to distinguish between graphic-type objects, rather than text, and plot objects other than these graphic-type objects. The processing of graphics is distributed suitably on the host and printer sides. In order to speed up processing, in this embodiment processing is executed based upon a rectangular area that contains the plot object. However, an arrangement may be adopted in which any polygon of rendered polygons is subjected to area judgment in strict fashion.

According to this embodiment, it is assumed that the plot processor within the printer is the plot processing execution unit when PDL-type processing is executed. However, an

arrangement may be adopted in which data processing is executed via a network using a module, which is referred to as an RIP (Raster Image Processor), that runs on another personal computer. Adopting such an arrangement makes it possible to implement the present invention in a case where processing capability on the side of the host computer is sufficiently high and in a case where the printer side does not possess a plot processing execution unit.

According to the second embodiment, area management is carried out dividing the area within a band into ten areas of the kind shown in FIG. 13. However, by adaptively changing the number of area partitions in dependence upon the application software, the fineness of discriminated areas will be decided in dependence upon the image. As a result, the strictness of discrimination is raised as necessary and it becomes possible to tune performance to the optimum level. For example, discrimination is made finer for spreadsheet software which involves a large quantity of text and coarser in a draw system in which not that much text is used. Thus, performance may be tuned adaptively.

<Other Embodiments>

The present invention can be applied to a system constituted by a plurality of devices (e.g., a host computer, interface, reader, printer, etc.) or to an apparatus comprising a single device (e.g., a copier or facsimile machine, etc.).

Furthermore, it goes without saying that the object of the invention is attained by supplying a storage medium storing the program codes of the software for performing the functions of the foregoing embodiments to a system or an apparatus, reading the program codes with a computer (e.g., a CPU or MPU) of the system or apparatus from the storage medium, and then executing the program codes.

In this case, the program codes read from the storage medium implement the novel functions of the invention, and the storage medium storing the program codes constitutes the invention.

Further, the storage medium, such as a floppy disk, hard disk, optical disk, magneto-optical disk, CD-ROM, CD-R, magnetic tape, non-volatile type memory card or ROM can be used to provide the program codes.

Furthermore, besides the case where the aforesaid functions according to the embodiments are implemented by executing the program codes read by a computer, it goes without saying that the present invention covers a case where an operating system or the like running on the computer performs a part of or the entire process in accordance with the designation of program codes and implements the functions according to the embodiments.

It goes without saying that the present invention further covers a case where, after the program codes read from the storage medium are written in a function extension board inserted into the computer or in a memory provided in a function extension unit connected to the computer, a CPU or the like contained in the function extension board or function extension unit performs a part of or the entire process in accordance with the designation of program codes and implements the function of the above embodiments.

In a case where the present invention is applied to the above-mentioned storage medium, program code corresponding to the flowcharts described above is stored on the storage medium. That is, the modules shown in the example of the memory map of FIG. 25 are stored on the storage medium. Specifically, it will suffice to store program code of at least a "print information generating module 2501", an "area information registration module 2502" and an "area discrimination module 2503" on the storage medium.

Thus, as described above, the information of each DDI is processed sequentially without being spooled, the largest area of a plot object other than text (i.e., other than DrvTextOut) is obtained on each occasion, this area is managed as several sub-areas obtained by partitioning in advance, overlap with this area is checked in DrvTextOut, text in a portion where there is overlap is sent to the printer upon being subjected to image-type plot processing (execution of plot processing is performed in the plotter memory on the host side), and text in a portion where there is no overlap is sent to the printer upon being subjected to PDL-type processing (execution of plot processing is performed in the plotter memory on the printer side), whereby high-speed print processing is executed. Since hatched patterns and ruled lines of a spreadsheet constituting background of text usually contain the text, the first and second embodiments are implemented on the precondition that text will come after also in a case where information is delivered as DDI.

In a case where the precondition does not hold, as indicated in the third embodiment, the correctness of printed results can be assured though there is a possibility of some decline in printing performance.

By adopting an arrangement in which the best components of image-type processing and PDL-type processing are switched between in appropriate fashion, the following effects can be expected:

② In a case where characters not having background are removed from a document, it is possible to eliminate redundant printing of characters that span bands, even in image-type processing.

② In comparison with a driver in which it is possible to separate only characters in an area in which there is no background and images and text are printed by having the user switch between image-type and PDL-type processing, the burden of making the switch is eliminated and suitable performance is achieved.

In particular, it is possible to provide a driver having excellent balance and exhibiting the advantages of both an image-type driver suited to highly complicated drawing high resolution Image processing and a PDL-type driver suited to printing text. This makes it possible to implement print processing at a speed higher than that of the prior art.

The present invention is not limited to the above embodiments and various changes and modifications can be made within the spirit and scope of the present invention. Therefore, to appraise the public of the scope of the present invention, the following claims are made.

What is claimed is:

1. A printing system constituted by a printing apparatus and a data processing apparatus capable of communicating with said printing apparatus via a prescribed communications medium, said system comprising:

print information generating means for generating print information, which is to be printed by said printing apparatus, in response to a print request command;

area information registration means for registering, in a registration area, coordinate information of a plotting area of a print object generated as the print information; and

area discrimination means for comparing the coordinate information registered by said area information registration means with character-string print position information when the character string is printed, and discriminating whether these two items of information overlap;

wherein type of processing for printing the character string is switched based upon results of discrimination by said area discrimination means.

2. The system according to claim 1, further comprising:

first character printing means for printing a character pattern, which has been expanded on the side of said printing apparatus, if there is no overlap in the plotting area of the print object based upon results of discrimination performed by said area discrimination means; and

second character printing means for printing a character pattern, which has been expanded on the side of said data processing apparatus, as a bitmap image if there is overlap in the plotting area of the print object based upon results of discrimination performed by said area discrimination means.

3. The system according to claim 1, wherein said area information registration means performs registration using area information relating to a rectangle circumscribing the plot object.

4. The system according to claim 1, wherein said area information registration means registers, in the registration area, minimum values of top-left coordinates and maximum values of bottom-right coordinates of a rectangle circumscribing each plot object that is possibly background of text.

5. The system according to claim 1, wherein said area discrimination means performs discrimination processing sequentially based upon print information generated sequentially in said print information generating means.

6. The system according to claim 1, wherein said print information generating means generates print information that has been rasterized in units obtained by partitioning one page into a plurality of band areas.

7. The system according to claim 1, wherein said print information generating means executes processing upon virtually connecting the plurality of band areas to expand them as one area in a case where a plotting area of a print object relating to a character bridges a plurality of the band areas according to the result of discrimination by said area discrimination means.

8. The system according to claim 1, wherein said area information registration means and said area discrimination means perform registration and discrimination upon partitioning and managing a band area in said print information generating means as a plurality of sub-areas.

9. The system according to claim 1, wherein said area information registration means saves, in the registration area, coordinate-value information which defines the maximum rectangular area that contains all print objects.

10. The system according to claim 1, wherein said registration area has:

a flag portion for identifying an attribute of the plotting area of the print object;

a parent-area portion for identifying a parent area when the plotting areas are connected;

a management area for saving coordinate information of the print object; and

a registration area for saving area information of background of the print object.

11. The system according to claim 1, wherein if said area discrimination means has discriminated overlap between an area of a character string processed as PDL and coordinate information of a subsequently entered print object which is background of the character string, said area discrimination means sets an image assurance flag for identifying the overlap and, after the image assurance flag has been set, subjects all print objects to print processing by said first character printing means, thereby eliminating inconsistency of printed results due to advance in the plotting order of the print objects.

12. The system according to claim 1, further comprising holding means for holding, on the side of said data processing apparatus, print information of a character string processed as PDL in the band area;

wherein if said area discrimination means has discriminated that the area of the character string processed as PDL and coordinate information of a subsequently entered print object which is background of the character string overlap, said area discrimination means calls the print information of the character string being held by said holding means, performs expansion in a plotter memory on the side of said data processing apparatus based upon the print information of the character string, and updates the coordinate information of the plotting area, which has been registered in the registration area, as well as the print information of the character string, thereby eliminating inconsistency of printed results due to advance in the plotting order of the print objects.

13. A print control method, comprising:

a print information generating step of generating print information, which is to be printed by a printing apparatus, in response to a print request command;

an area information registration step of registering, in a registration area, coordinate information of a plotting area of a print object generated as the print information; and

an area discrimination step of comparing the coordinate information registered at said area information registration step with character-string print position information when the character string is printed, and discriminating whether these two items of information overlap;

wherein type of processing for printing the character string is switched based upon results of discrimination.

14. The method according to claim 13, further comprising:

a first character printing step of printing a character pattern, which has been expanded on the side of the printing apparatus, if there is no overlap in the plotting area of the print object based upon results of discrimination performed at said area discrimination step; and

a second character printing step of printing a character pattern, which has been expanded on the side of the data processing apparatus, as a bitmap image if there is overlap in the plotting area of the print object based upon results of discrimination performed at said area discrimination step.

15. The method according to claim 13, wherein said area information registration step performs registration using area information relating to a rectangle circumscribing the plot object.

16. The method according to claim 13, wherein said area information registration step registers, in the registration area, minimum values of top-left coordinates and maximum values of bottom-right coordinates of a rectangle circumscribing each plot object that is possibly background of text.

17. The method according to claim 13, wherein said area discrimination step performs discrimination processing sequentially based upon print information generated sequentially at said print information generating step.

18. The method according to claim 13, wherein said print information generating step generates print information that

has been rasterized in units obtained by partitioning one page into a plurality of band areas.

19. The method according to claim 13, wherein said print information generating step executes processing upon virtually connecting the plurality of band areas to expand them as one area in a case where a plotting area of a print object relating to a character bridges a plurality of the band areas according to the result of discrimination at said area discrimination step.

20. The method according to claim 13, wherein said the area information registration step saves, in the registration area, coordinate-value information which defines the maximum rectangular area that contains all print objects.

21. The method according to claim 13, wherein the registration area has:

a flag portion for identifying an attribute of the plotting area of the print object;

a parent-area portion for identifying a parent area when the plotting areas are connected;

a management area for saving coordinate information of the print object; and

a registration area for saving area information of background of the print object.

22. The method according to claim 13, wherein if said area discrimination step has discriminated overlap between an area of a character string processed as PDL and coordinate information of a subsequently entered print object which is background of the character string, said area discrimination step sets an image assurance flag for identifying the overlap and, after the image assurance flag has been set, subjects all print objects to print processing by said first character printing step, thereby eliminating inconsistency of printed results due to advance in the plotting order of the print objects.

23. The method according to claim 13, further comprising a holding step of holding, in a memory on the side of the data processing apparatus, print information of a character string processed as PDL in the band area;

wherein if said area discrimination step has discriminated that the area of the character string processed as PDL and coordinate information of a subsequently entered print object which is background of the character string overlap, the area discrimination step calls the print information of the character string being held in the memory, performs expansion in a plotter memory on the side of the data processing apparatus based upon the print information of the character string, and updates the coordinate information of the plotting area, which has been registered in the registration area, as well as the print information of the character string, thereby eliminating inconsistency of printed results due to advance in the plotting order of the print objects.

24. A data processing apparatus for outputting print information to a printing apparatus via a prescribed communications medium, comprising:

print information generating means for generating print information that is to be printed by said printing apparatus;

area information registration means for registering, in a registration area, coordinate information of a plotting area of the print information that has been generated;

area information updating means which, when the coordinate information is registered, is for updating the coordinate information as the maximum area that contains the plotting area; and

area discrimination means for comparing the coordinate information registered by said area information registration means with character-string print position information when the character string is printed, and discriminating whether these two items of information overlap.

25. A data processing method for processing print information that is output to a printing apparatus, comprising:

a print information generating step of generating print information that is to be printed by the printing apparatus;

an area information registration step of registering, in a registration area, coordinate information of a plotting area of the print information that has been generated;

an area information updating step which, when the coordinate information is registered, is a step of updating the coordinate information as the maximum area that contains the plotting area; and

an area discrimination step of comparing the coordinate information registered at said area information registration step with character-string print position information when the character string is printed, and discriminating whether these two items of information overlap.

26. A storage medium storing a data processing program for processing print information that is output to a printing apparatus, the data processing program comprising:

code of a print information generating step of generating print information that is to be printed by the printing apparatus;

code of an area information registration step of registering, in a registration area, coordinate information of a plotting area of the print information that has been generated;

code of an area information updating step which, when the coordinate information is updated, is a step of updating the coordinate information as the maximum area that contains the plotting area; and

code of an area discrimination step of comparing the coordinate information registered at said area information registration step with character-string print position information when the character string is printed, and discriminating whether these two items of information overlap.

27. A storage medium storing a print control program, comprising:

code of a print information generating step of generating print information, which is to be printed by a printing apparatus, in response to a print request command;

code of an area information registration step of registering, in a registration area, coordinate information of a plotting area of a print object generated as the print information.

28. The system according to claim 1, wherein said area discrimination means performs discrimination processing based upon print information without spooling.

29. The method according to claim 13, wherein said area discrimination step performs discrimination processing based upon print information without spooling.

30. The storage medium according to claim 27, wherein said code of area discrimination step performs discrimination processing based upon print information without spooling.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,535,293 B1
DATED : March 18, 2003
INVENTOR(S) : Mitsuhashi

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 10,
Line 38, "being had" should be deleted.

Column 15,
Line 16, "SUB-AREA type" should read -- SUB-AREA-type --.

Column 17,
Line 64, "parent area" should read -- parentArea --.

Column 18,
Line 60, "parent area" should read -- parentArea --.

Column 22,
Line 28, the encircled number "2" should be an encircled number -- 1 --.

Signed and Sealed this

Sixteenth Day of December, 2003

JAMES E. ROGAN
Director of the United States Patent and Trademark Office